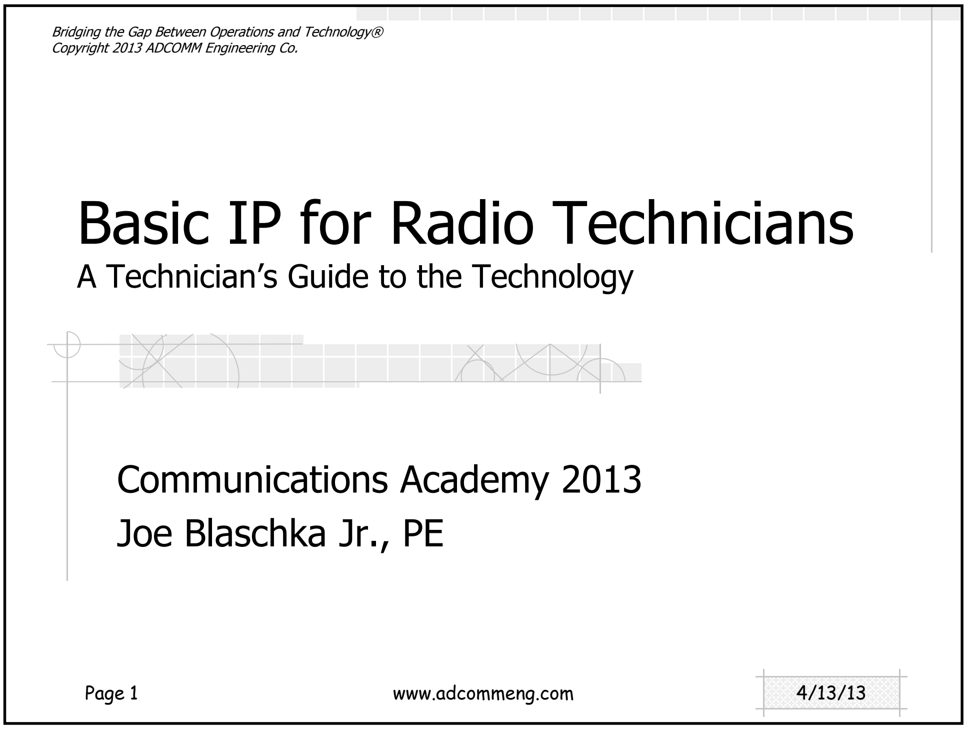
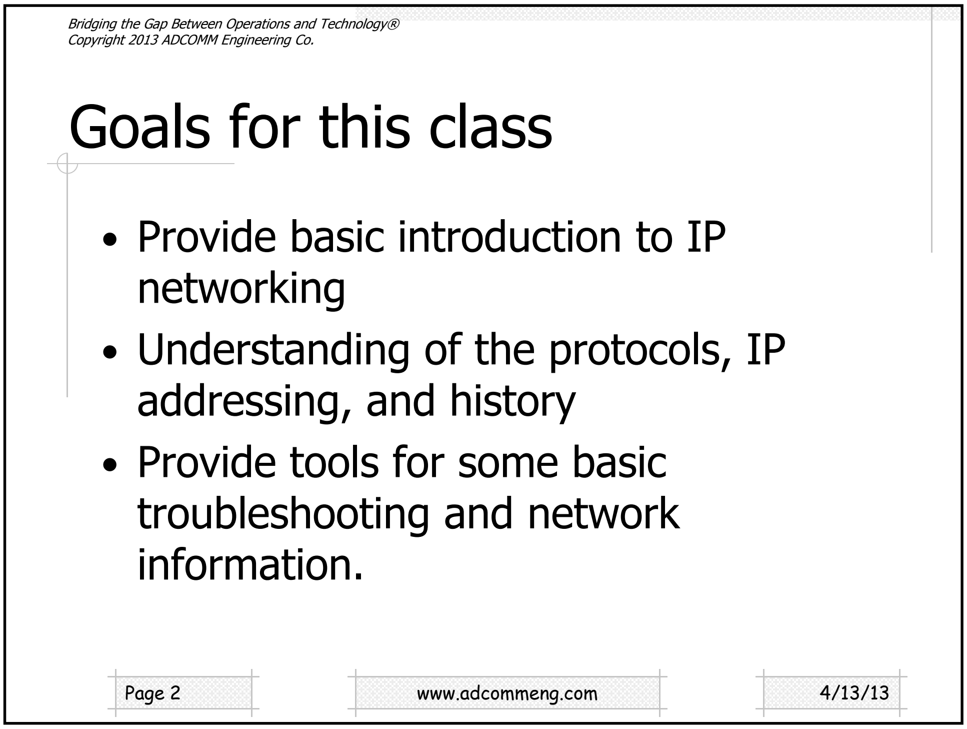


Basic IP for Radio Technicians

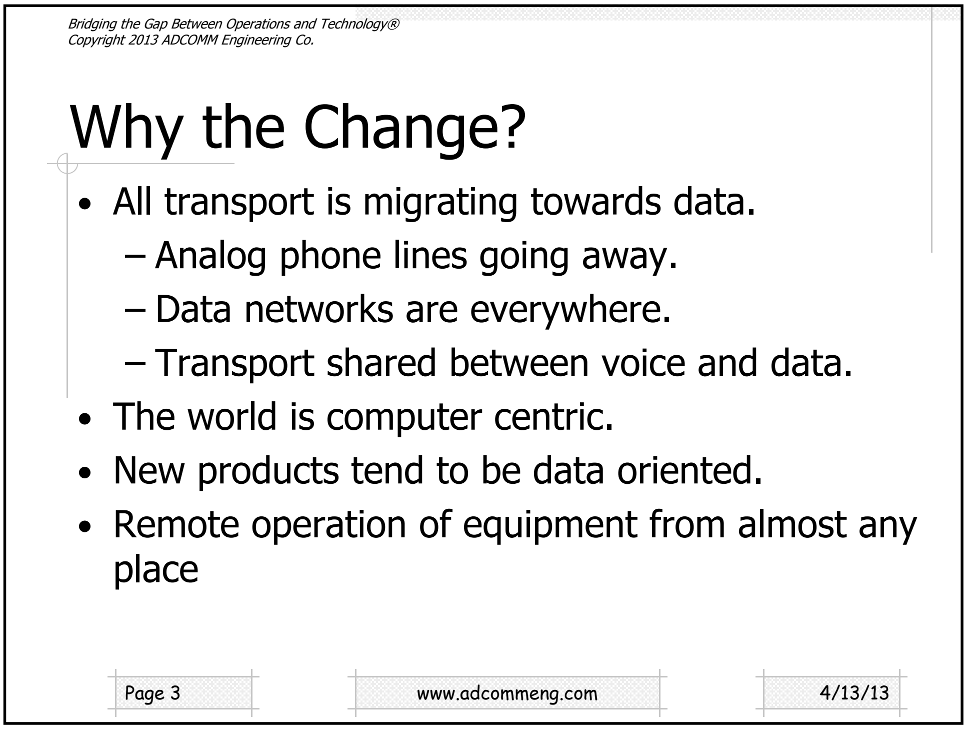
A Technician's Guide to the Technology

Communications Academy 2013
Joe Blaschka Jr., PE



Goals for this class

- Provide basic introduction to IP networking
- Understanding of the protocols, IP addressing, and history
- Provide tools for some basic troubleshooting and network information.



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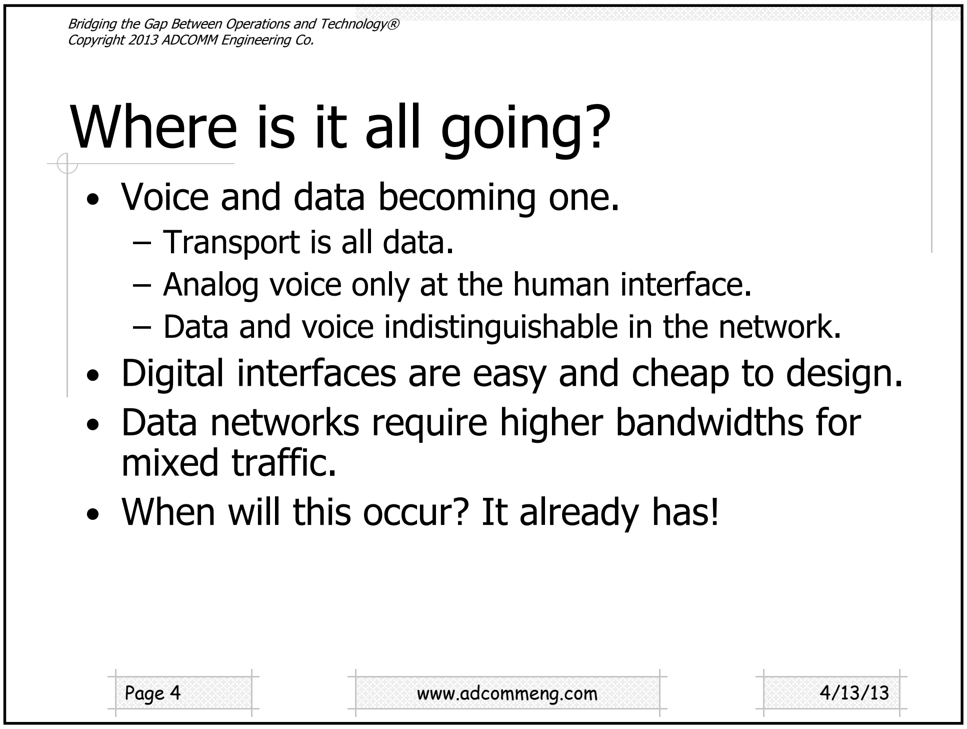
Why the Change?

- All transport is migrating towards data.
  - Analog phone lines going away.
  - Data networks are everywhere.
  - Transport shared between voice and data.
- The world is computer centric.
- New products tend to be data oriented.
- Remote operation of equipment from almost any place



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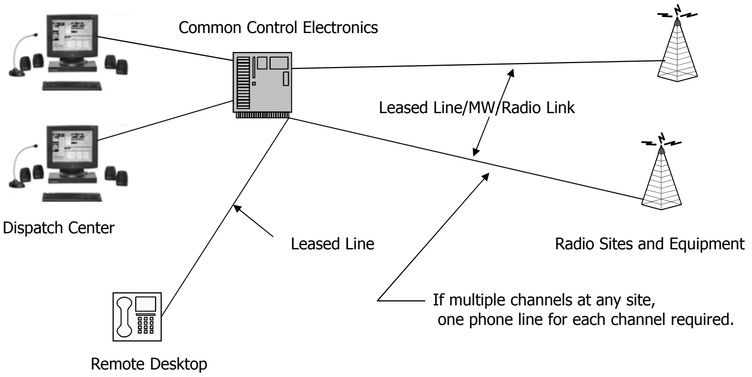
Where is it all going?

- Voice and data becoming one.
  - Transport is all data.
  - Analog voice only at the human interface.
  - Data and voice indistinguishable in the network.
- Digital interfaces are easy and cheap to design.
- Data networks require higher bandwidths for mixed traffic.
- When will this occur? It already has!

Why IP?

- Typical radio network today



Common Control Electronics

Leased Line/MW/Radio Link

Dispatch Center

Leased Line

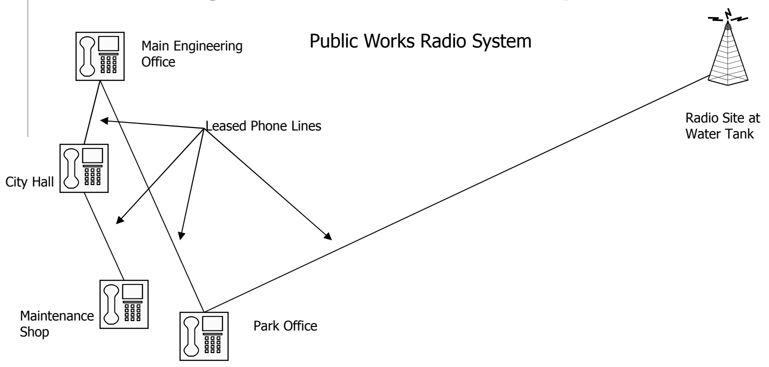
Radio Sites and Equipment

If multiple channels at any site,
one phone line for each channel required.

Remote Desktop

Why IP?

- Analog connections today.



Main Engineering Office

Public Works Radio System

Leased Phone Lines

Radio Site at Water Tank

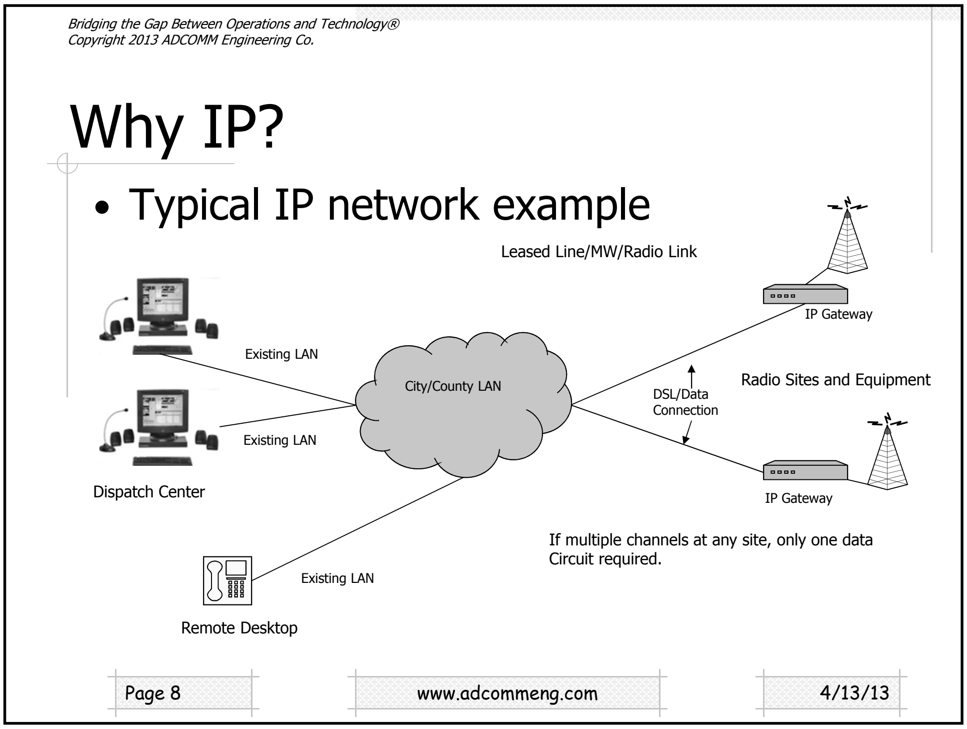
City Hall

Maintenance Shop

Park Office

Why IP?

- What do those examples have in common?
  - Use of dedicated phone lines or other interconnection method for each site/channel
  - Use of dedicated phone lines to interconnect remote console positions
  - High on-going costs for dedicated facilities
  - Loss of one connection point could cause loss of communications
  - Dedicated facilities are expensive



Why IP?

- Typical IP network example

If multiple channels at any site, only one data Circuit required.

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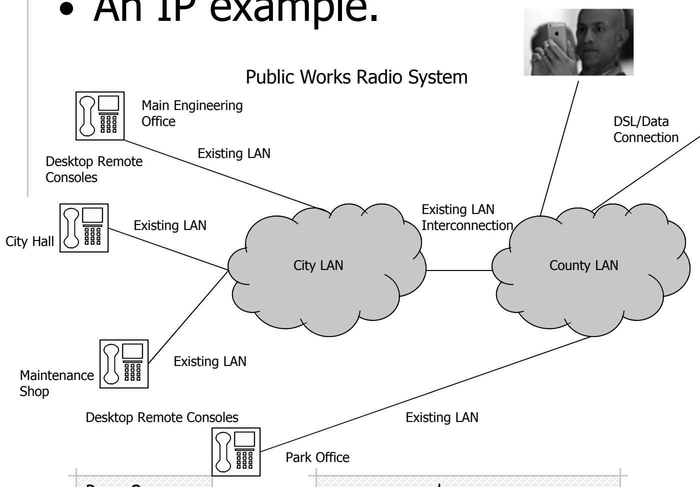
Why IP?

- An IP example.



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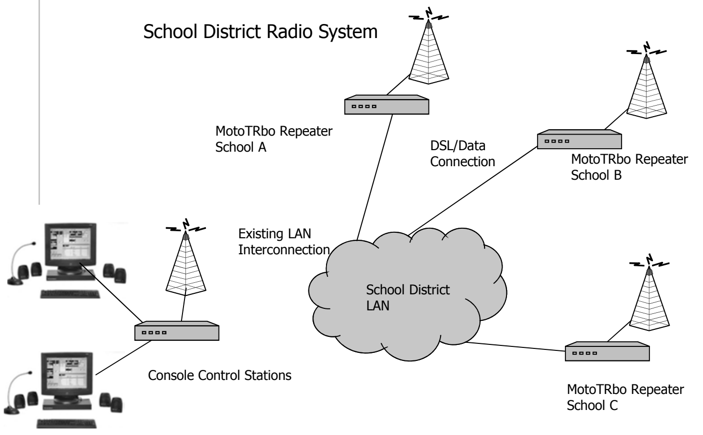
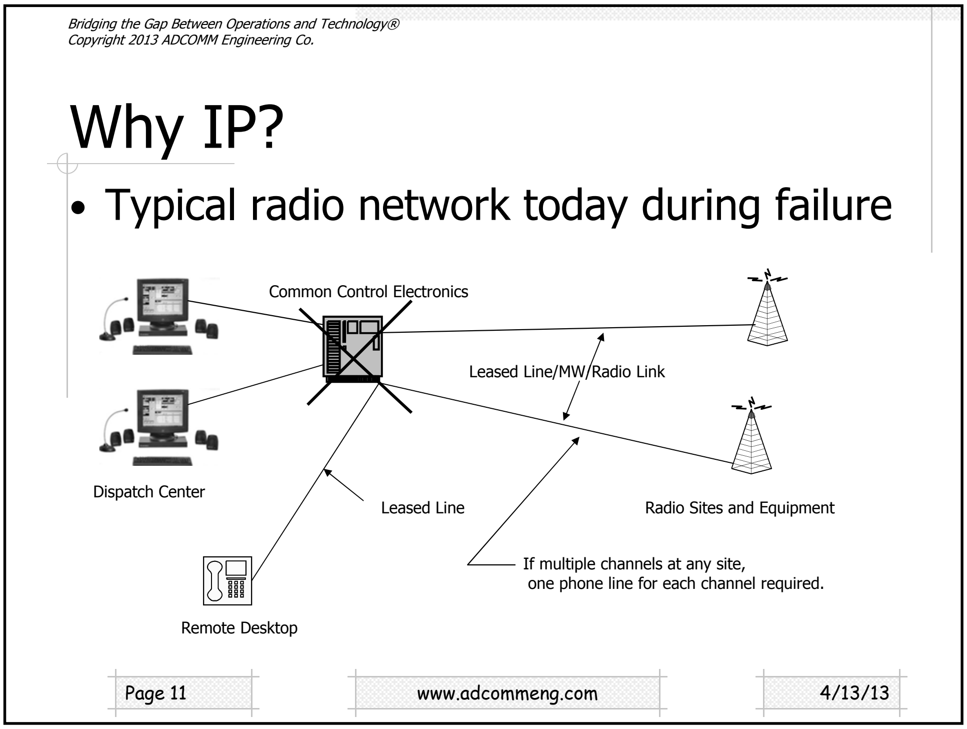
IP Network Example


School District Radio System
MotoTRbo Repeater School A
DSL/Data Connection
MotoTRbo Repeater School B
Existing LAN Interconnection
School District LAN
Console Control Stations
MotoTRbo Repeater School C



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Why IP?

- Typical radio network today during failure

Common Control Electronics

Leased Line/MW/Radio Link

Dispatch Center

Leased Line

Radio Sites and Equipment

If multiple channels at any site,
one phone line for each channel required.

Remote Desktop

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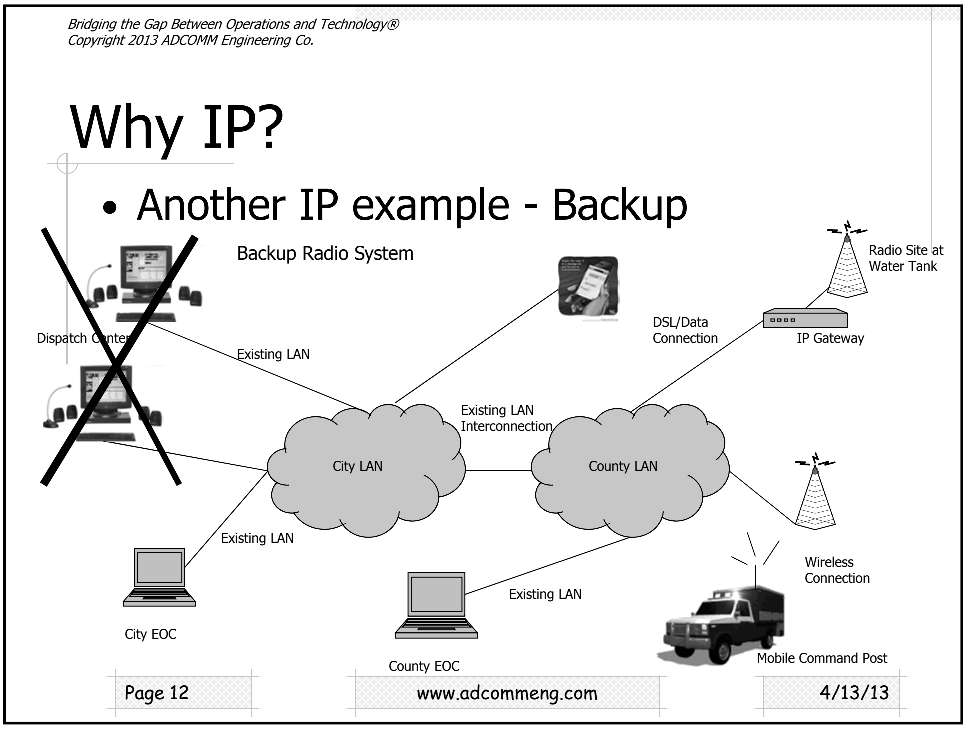

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Why IP?

- Another IP example - Backup

Backup Radio System

Radio Site at
Water Tank

Dispatch Center

DSL/Data
Connection

IP Gateway

Existing LAN

Existing LAN
Interconnection

City LAN

County LAN

Existing LAN

Wireless
Connection

Existing LAN

City EOC

County EOC

Mobile Command Post

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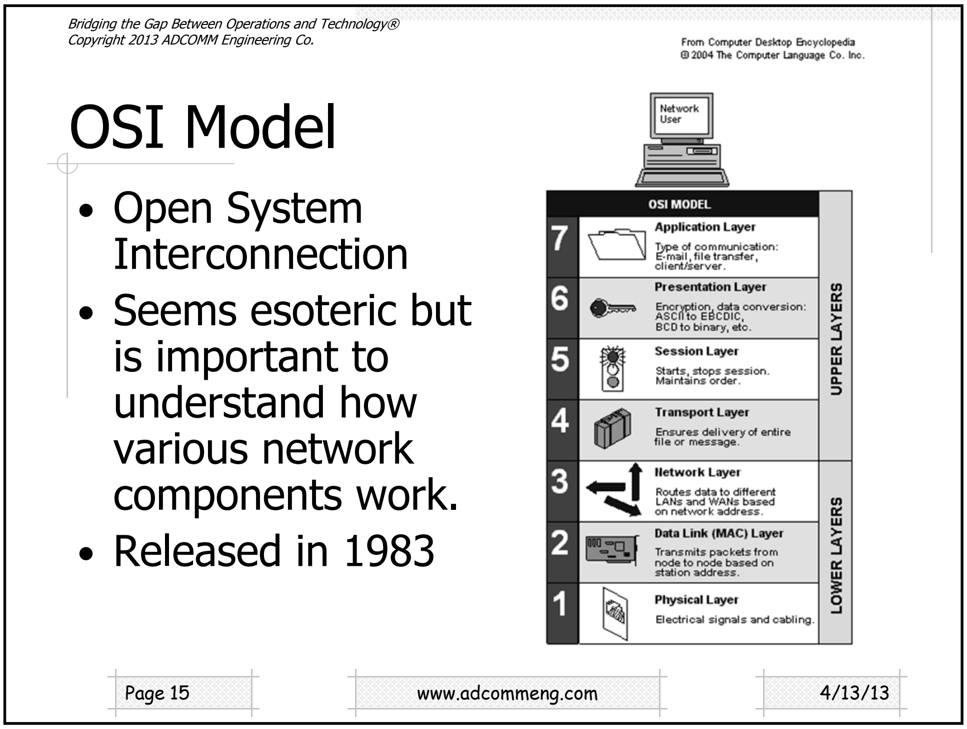
How can IP be used for radio?

- It is a method of interconnecting consoles, radios, telephones, and other devices
- It is not transmitted over-the-air to the user radios
- IP ≠ P25
- Uses standard Internet Protocols (IP)
  - TCP/IP – Most reliable format because provides guaranteed delivery but not generally used for voice because of bandwidth
  - UDP/IP – Uses less bandwidth but may be less reliable because no guaranteed delivery
  - Uses many of the standards and protocols available in most data networks but not necessarily allowed by the network manager

The Promise of IP

- Reduces costs because existing data networks can be used
- Easy to use, interconnects many different brands of equipment
- Control consoles can be located anywhere there is a data network and a simple laptop can be used
- Reduces costs because standard computer hardware can be used
- Great for disaster recovery and back up because IP data networks are often more resilient than voice or dedicated facilities
- Reduces costs because one data circuit can handle multiple base stations
- Interconnects many different kinds of equipment such as cell phones, 2-way radio, Internet Phones, VoIP phones, etc.
- Plug and Play



OSI Model

- Open System Interconnection
- Seems esoteric but is important to understand how various network components work.
- Released in 1983

From Computer Desktop Encyclopedia
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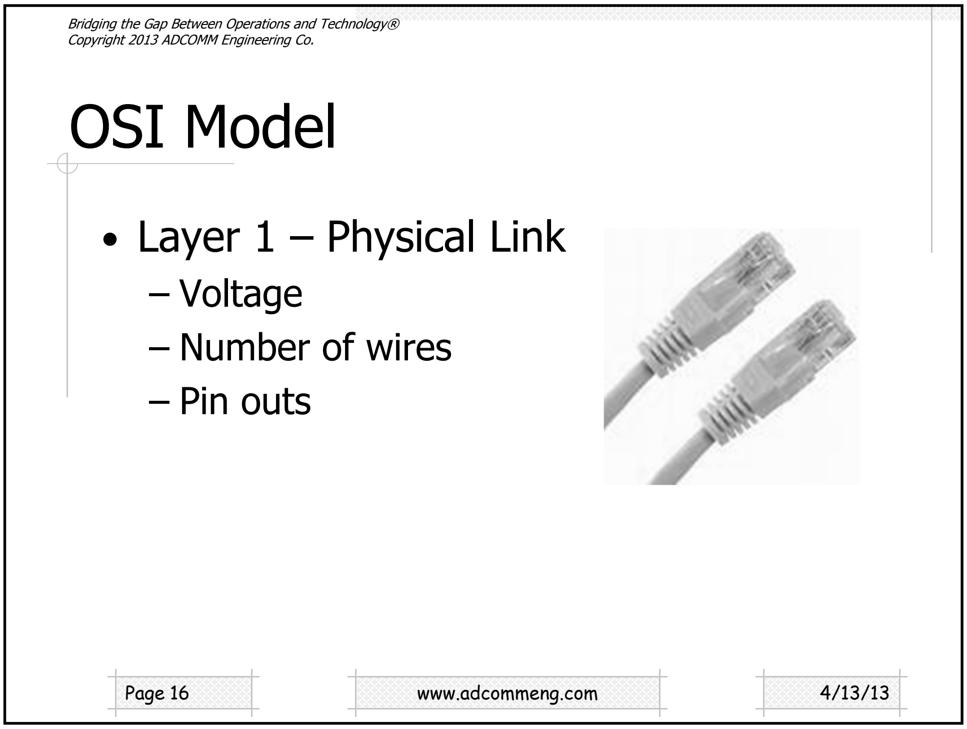
Network User

OSI MODEL

7 **Application Layer** Type of communication: E-mail, file transfer, client/server.
6 **Presentation Layer** Encryption, data conversion: ASCII to EBCDIC, BCD to binary, etc.
5 **Session Layer** Starts, stops session. Maintains order.
4 **Transport Layer** Ensures delivery of entire file or message.
3 **Network Layer** Routes data to different LANs and WANs based on network address.
2 **Data Link (MAC) Layer** Transmits packets from node to node based on station address.
1 **Physical Layer** Electrical signals and cabling.

UPPER LAYERS
LOWER LAYERS



OSI Model

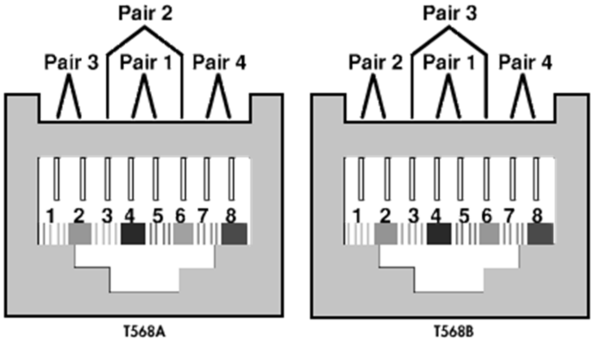
- Layer 1 – Physical Link
  - Voltage
  - Number of wires
  - Pin outs

Layer 1 Wiring

- Layer 1 Wiring standards
- Connector 8P8C (not really RJ45)
  - TIA 568A
    - Recommended for general use
    - Compatible with T1 USOC RJ-48C
    - Recommended for home networks TIA 570
    - Compatible with voice telephone line RJ11 type connections
  - TIA 568B
    - Most common in commercial applications
    - Legacy "Bell System" wiring (Merlin systems)

Layer 1 Wiring

- TIA 568 Pin outs

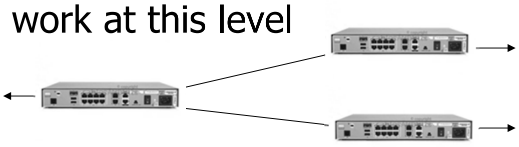


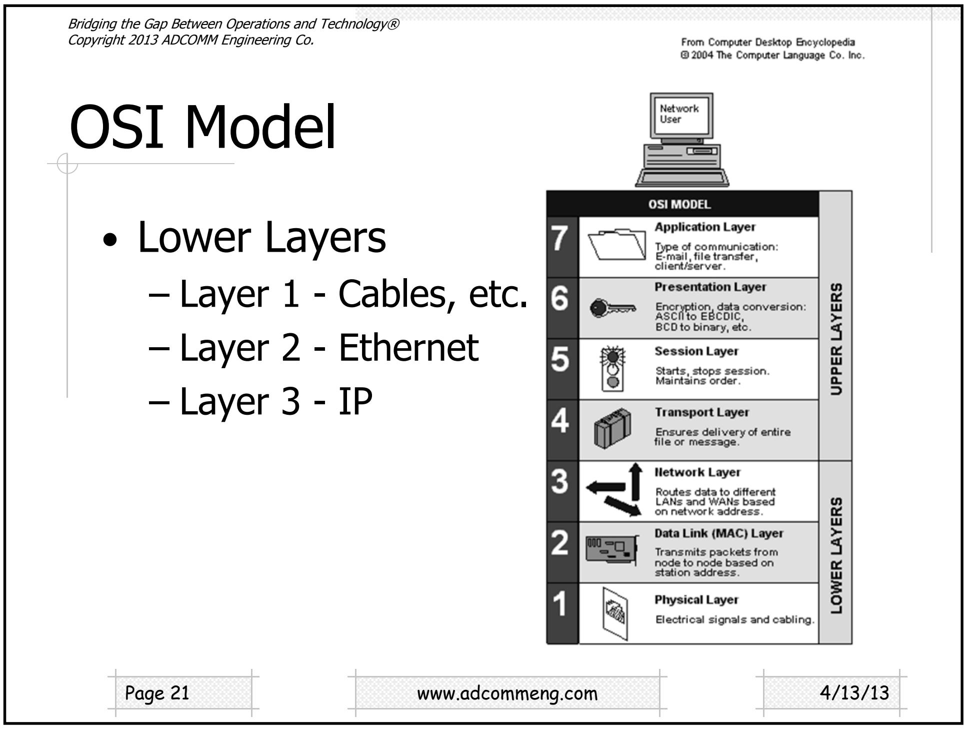
OSI Model

- Layer 2 – Data Link
  - Media Access Control (MAC) Addresses
  - Ethernet, Token Ring, Frame Relay, ATM
  - Data “Switches” usually work at this level
  - LAN Cards – Usually Layer 2 depending on card
  - Ethernet uses Carrier Sense Multiple Access with Collision Detection (CSMA-CD)

OSI Model

- Layer 3 – Network Layer
  - Higher level addressing
  - Handles communications between network switching points.
  - Routers generally operate at this level
  - IP, SNA, Apple Talk
  - IP addresses work at this level





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OSI Model

- Lower Layers
  - Layer 1 - Cables, etc.
  - Layer 2 - Ethernet
  - Layer 3 - IP

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Network User
OSI MODEL
7 Application Layer
Type of communication: E-mail, file transfer, client/server.
6 Presentation Layer
Encryption, data conversion: ASCII to EBCDIC, BCD to binary, etc.
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Starts, stops session. Maintains order.
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Ensures delivery of entire file or message.
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UPPER LAYERS
LOWER LAYERS

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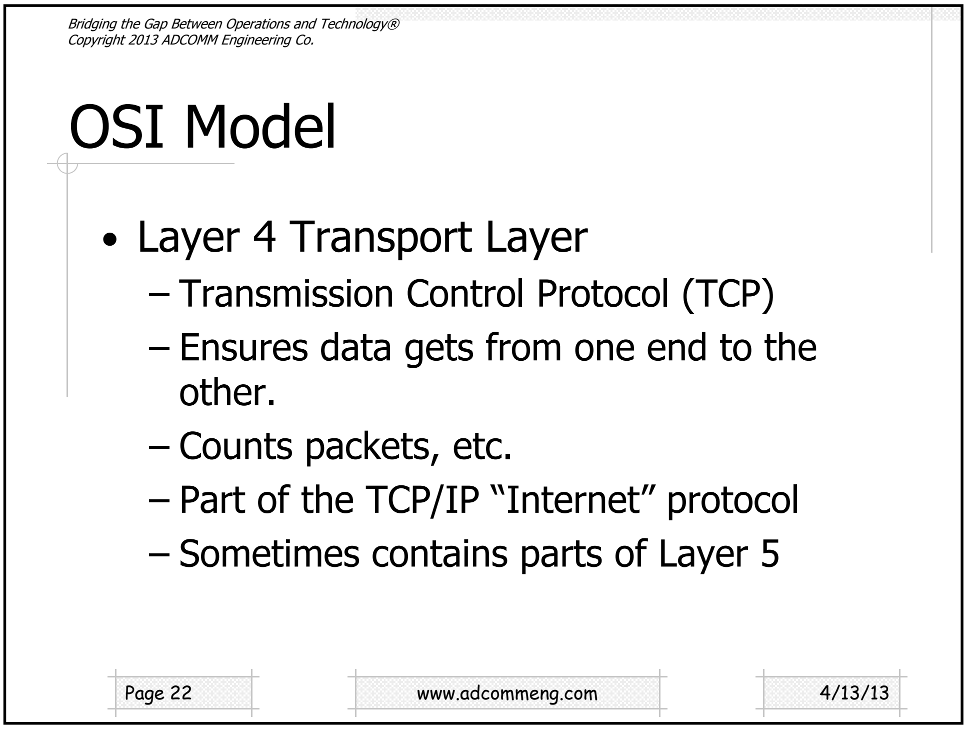

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OSI Model

- Layer 4 Transport Layer
  - Transmission Control Protocol (TCP)
  - Ensures data gets from one end to the other.
  - Counts packets, etc.
  - Part of the TCP/IP “Internet” protocol
  - Sometimes contains parts of Layer 5

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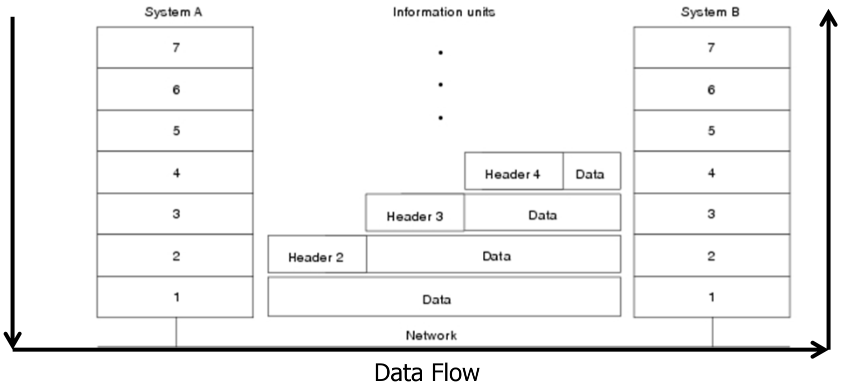
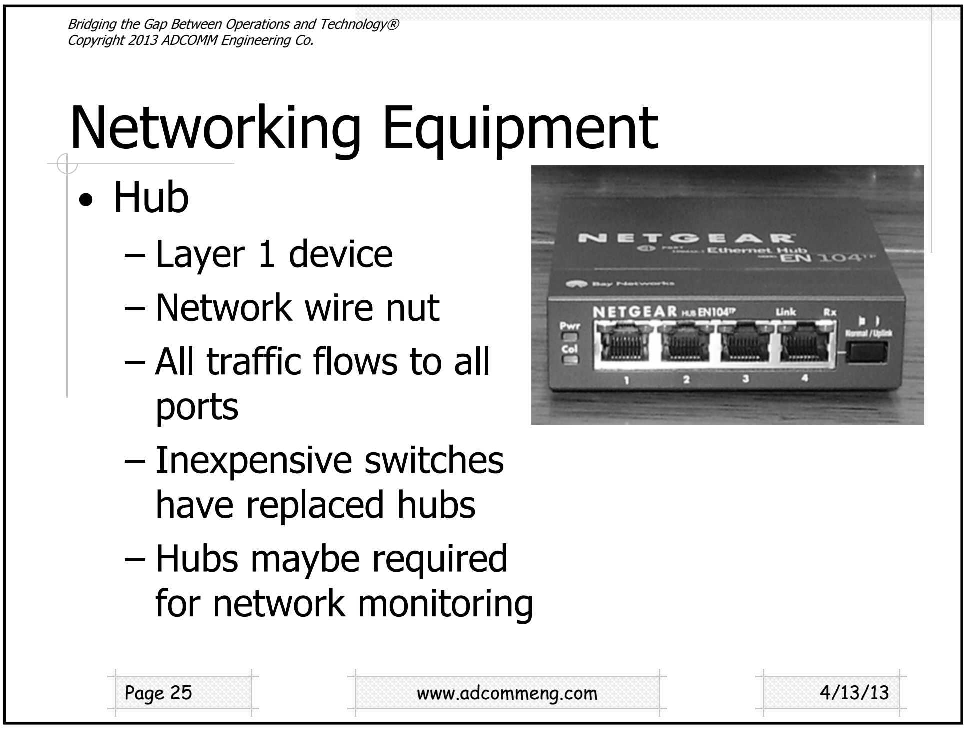
OSI Model

- Layer 5 – Session Layer
  - Manages two-way or one-way transmission
  - Provides communications coordination
  - Often incorporated in Layer 4
- Layer 6 – Presentation Layer
  - Use has changed over time
  - Generally used for encryption now.
- Layer 7 – Application Layer
  - Used to manage the applications such as file transfers, etc.
- Layers 5, 6, and 7 are often merged together in the operating system or applications in modern computers.

Network Data Flow

- Data flows through the OSI model elements.





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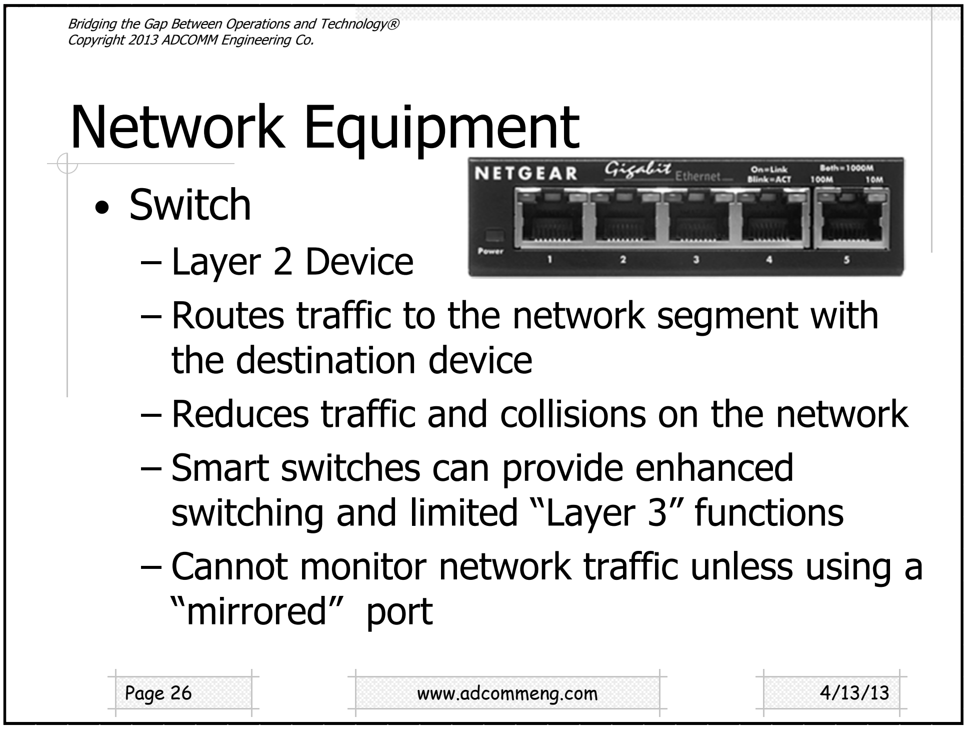
Networking Equipment

- Hub
  - Layer 1 device
  - Network wire nut
  - All traffic flows to all ports
  - Inexpensive switches have replaced hubs
  - Hubs maybe required for network monitoring

NETGEAR
Ethernet Hub
EN 104TP
Bay Networks
NETGEAR HUB EN104TP
Link
Rx
Pwr
Col
Normal / Uplink
1
2
3
4



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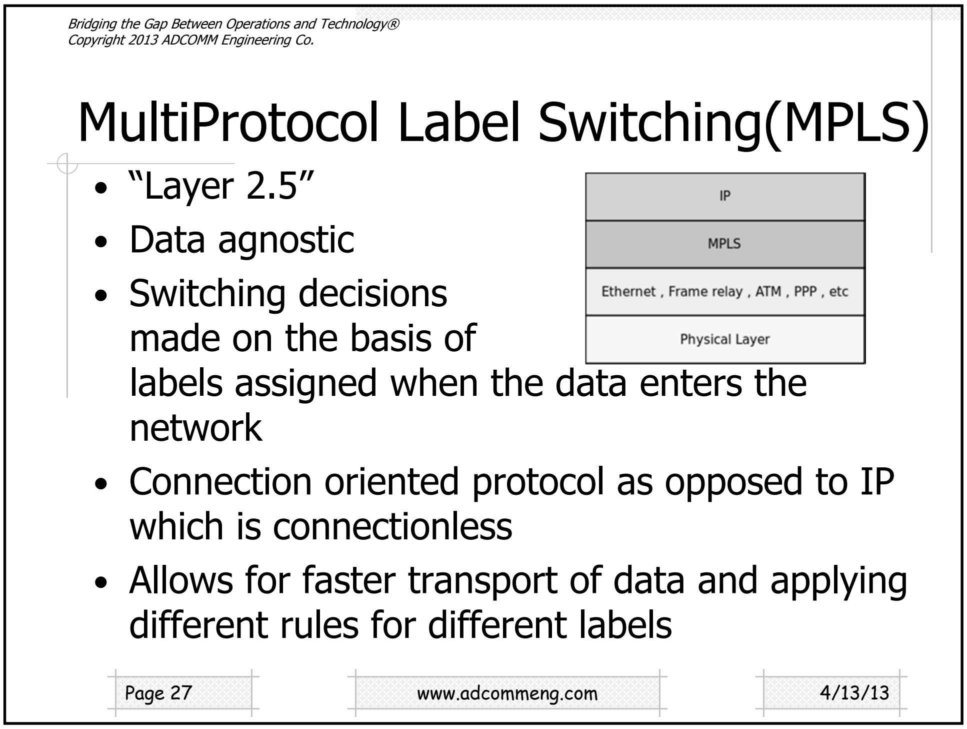
Network Equipment

- Switch
  - Layer 2 Device
  - Routes traffic to the network segment with the destination device
  - Reduces traffic and collisions on the network
  - Smart switches can provide enhanced switching and limited "Layer 3" functions
  - Cannot monitor network traffic unless using a "mirrored" port



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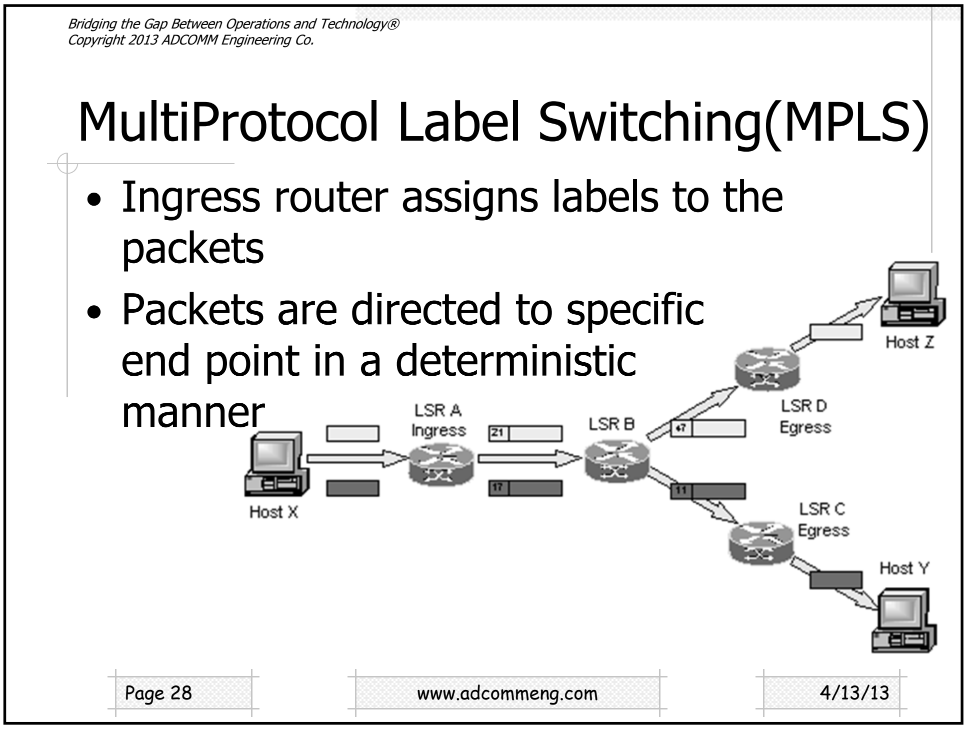
MultiProtocol Label Switching(MPLS)

- "Layer 2.5"
- Data agnostic
- Switching decisions made on the basis of labels assigned when the data enters the network
- Connection oriented protocol as opposed to IP which is connectionless
- Allows for faster transport of data and applying different rules for different labels



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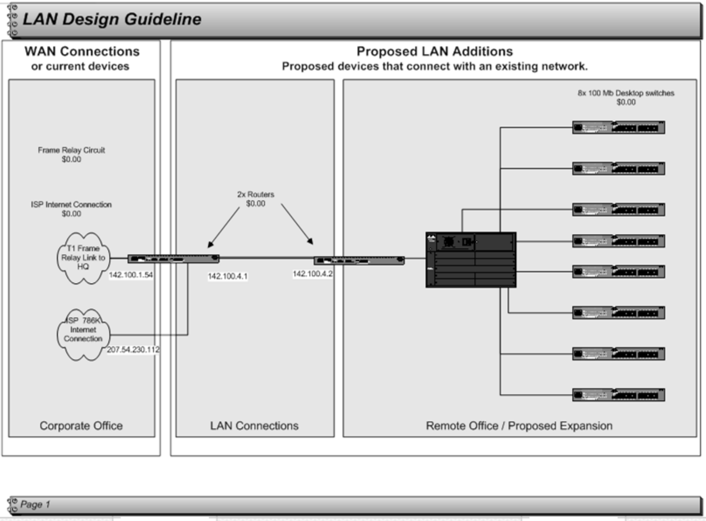
MultiProtocol Label Switching(MPLS)

- Ingress router assigns labels to the packets
- Packets are directed to specific end point in a deterministic manner

Networking Equipment

- Routers
  - Layer 3 Device
  - Connects one network to another
  - Usually provides transport conversion
  - Makes “intelligent” decisions about how to route data

Putting it all together

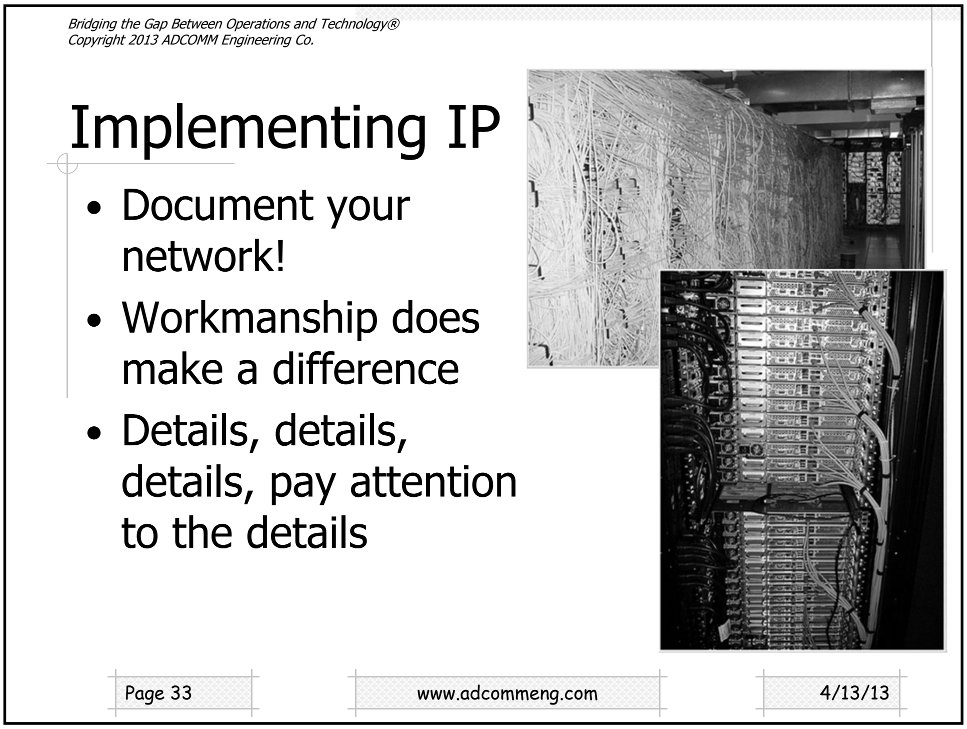


Initial Considerations

- Shared or dedicated network
- Shared network should support
  - Multicast – Transmits to multiple points simultaneously
  - Bandwidth – Depends on vocoding assume 50k per voice channel worst case
  - Fixed IP addresses
  - Dedicated bandwidth or Quality of Service
  - Virtual LAN's do not guarantee bandwidth
  - Delay must be controlled
  - Router/Firewall programming control
  - Security and virus protection

Technical Details

- Data Networking
  - Common use:
    - TCP/IP for control signals – More reliable
    - UDP/IP for voice data – Less bandwidth
    - Multicast – Routing data to multiple points
    - Fixed IP addresses
    - Be careful with any network assumptions as different vendors have implemented network interfaces differently.
  - Quality of service is generally required to ensure delivery of audio packets. (Remember they are UDP/IP.)
  - Multiple ports may need to be opened in firewalls, etc. for proper operation.
  - Virtual LANs do not guarantee bandwidth.
  - Network security must be managed.

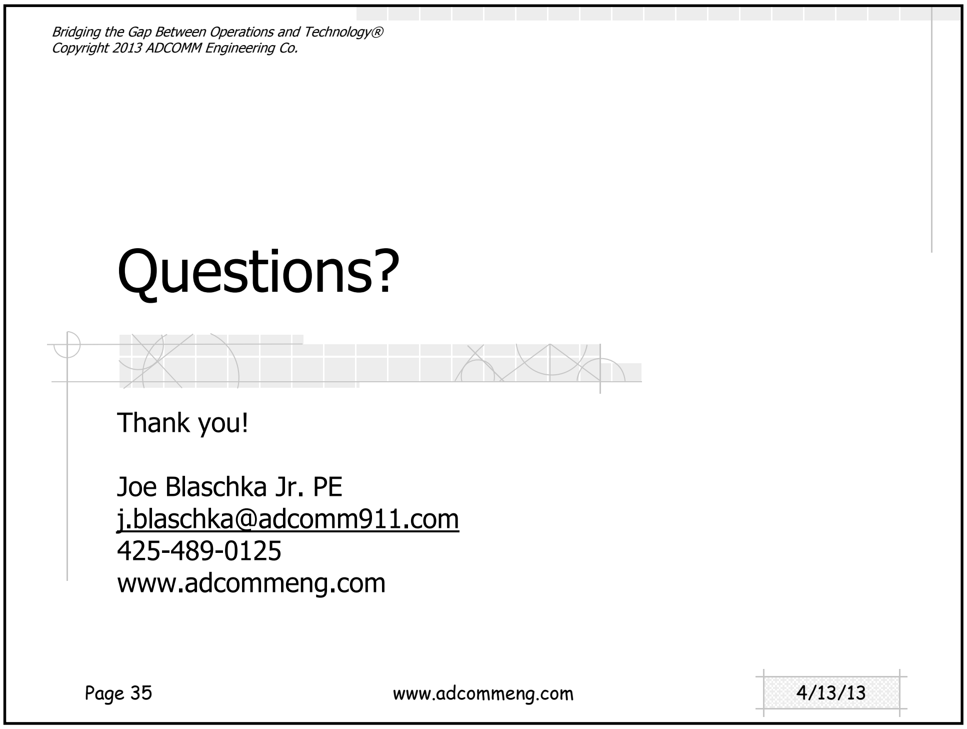


Implementing IP

- Document your network!
- Workmanship does make a difference
- Details, details, details, pay attention to the details

IP – The Future is Now

- Good news
  - Can be a very cost effective solution in some situations
  - If limitations are not a problem, costs can be reduced
  - This technology will eventually become the dominate method for radio system interconnection because most communications are moving to an IP type network
  - Improvements in the interfaces are being made all the time
  - Some issues are resolved if implemented on a dedicated data network but that raises costs



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Questions?

Thank you!

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www.adcommeng.com

IP Network Basics

Communications Academy 2013
Dave Magnenat

Agenda

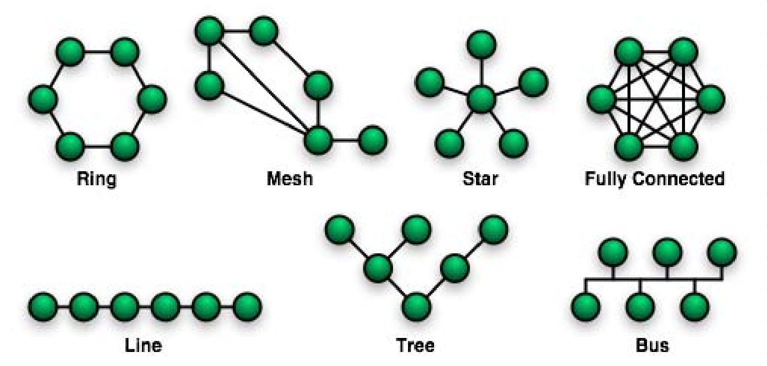
- Network characteristics
- Internetworking Protocol
- IP addressing & devices

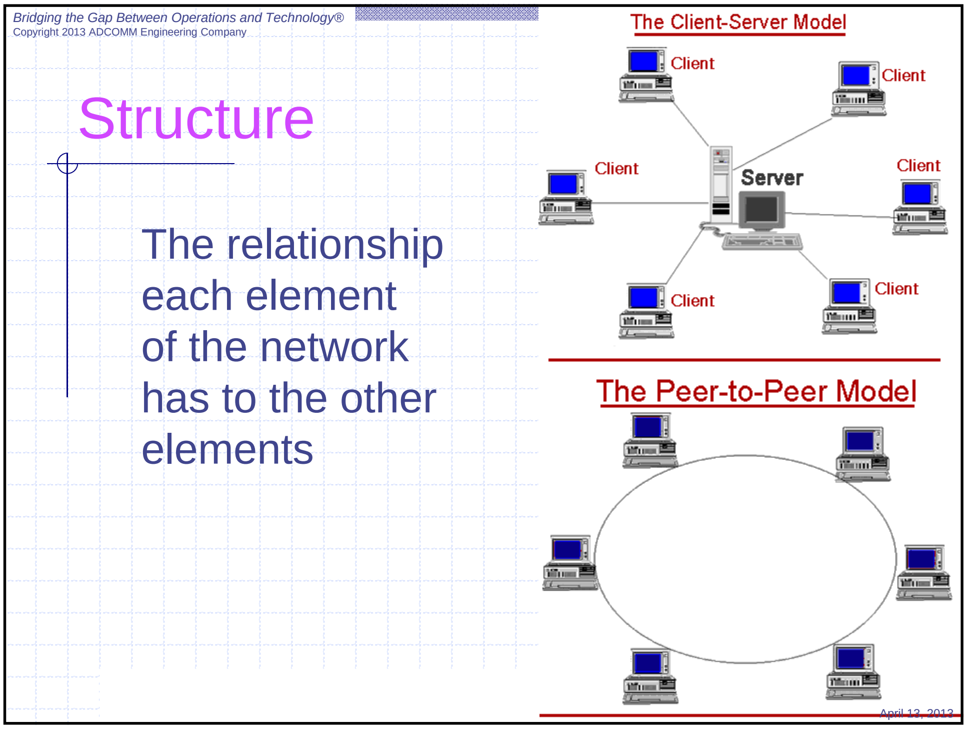
Network Characteristics

- Topology – what shape it is
- Structure – relationship between members
- Switching – pathways for moving information
- Protocol – rules for communication

Networks

- Topologies





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Structure

The relationship each element of the network has to the other elements

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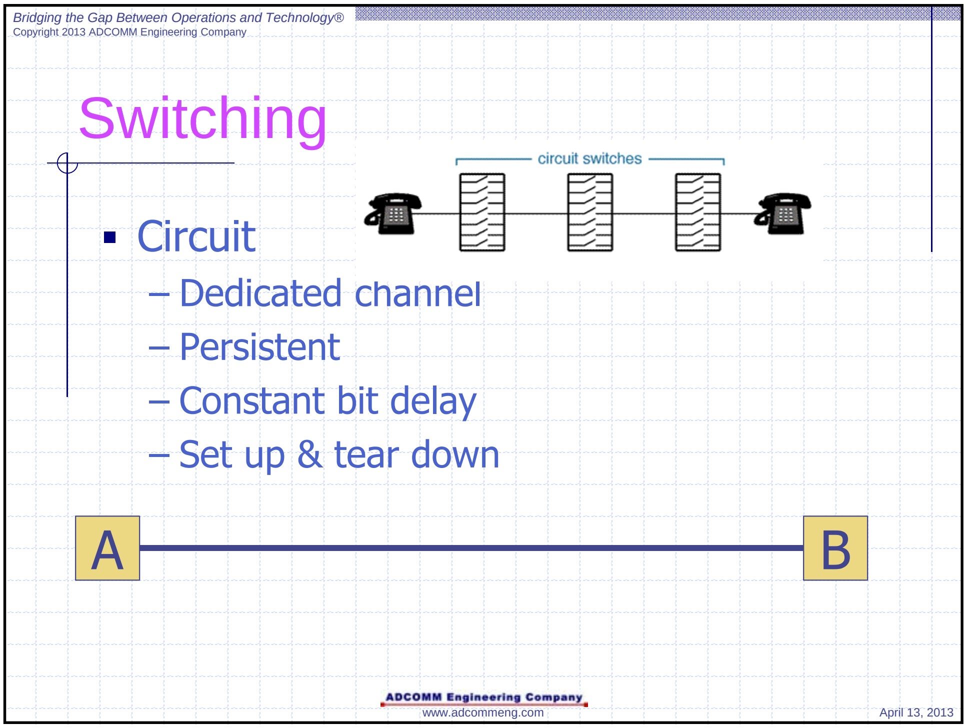

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Switching

- Circuit
  - – Dedicated channel
  - – Persistent
  - – Constant bit delay
  - – Set up & tear down

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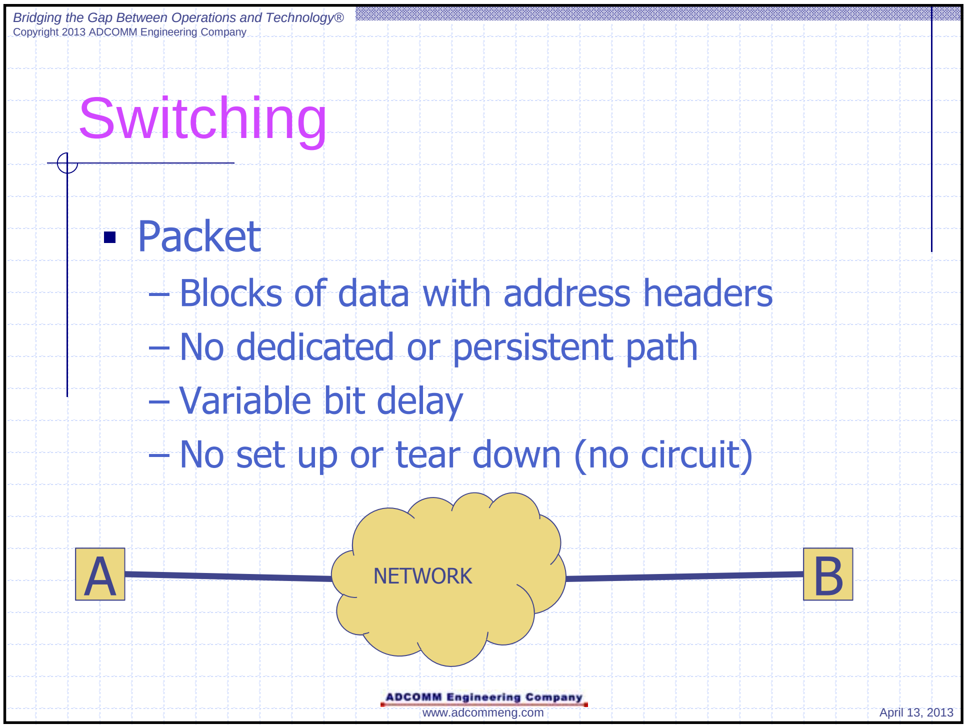
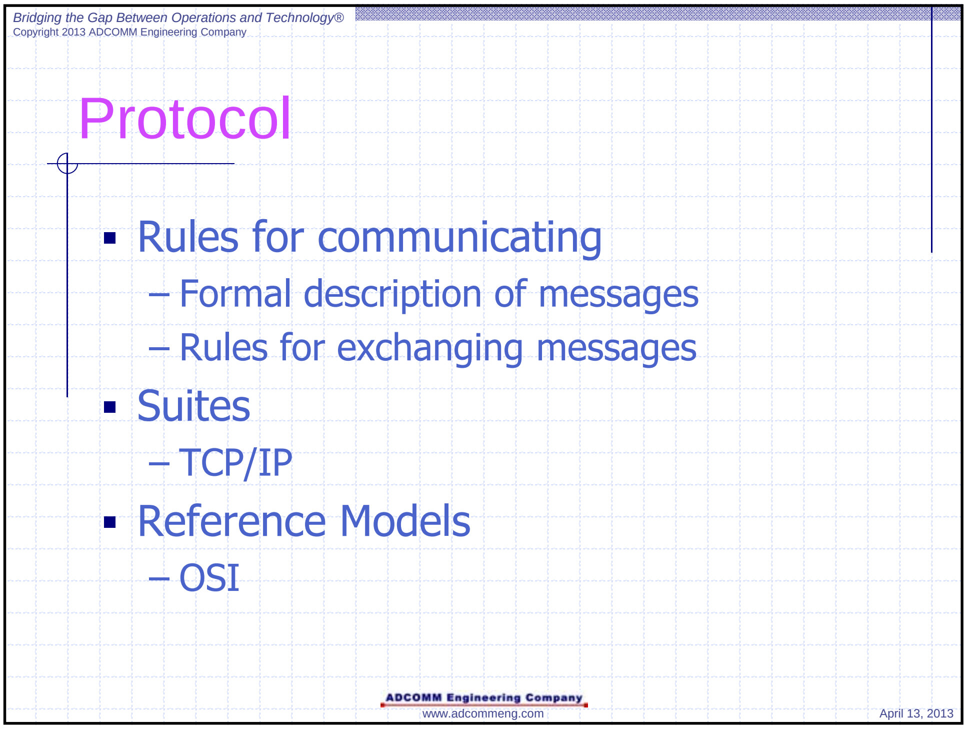
Switching

- Circuit
  - "Nailed up" "Copper" "Leased Line" "Point to Point"
- Virtual circuit
  - Setup before transmission
  - Persistent
  - Really connection-oriented packet switching



Switching

- Packet
  - Blocks of data with address headers
  - No dedicated or persistent path
  - Variable bit delay
  - No set up or tear down (no circuit)



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Protocol

- Rules for communicating
  - Formal description of messages
  - Rules for exchanging messages
- Suites
  - TCP/IP
- Reference Models
  - OSI

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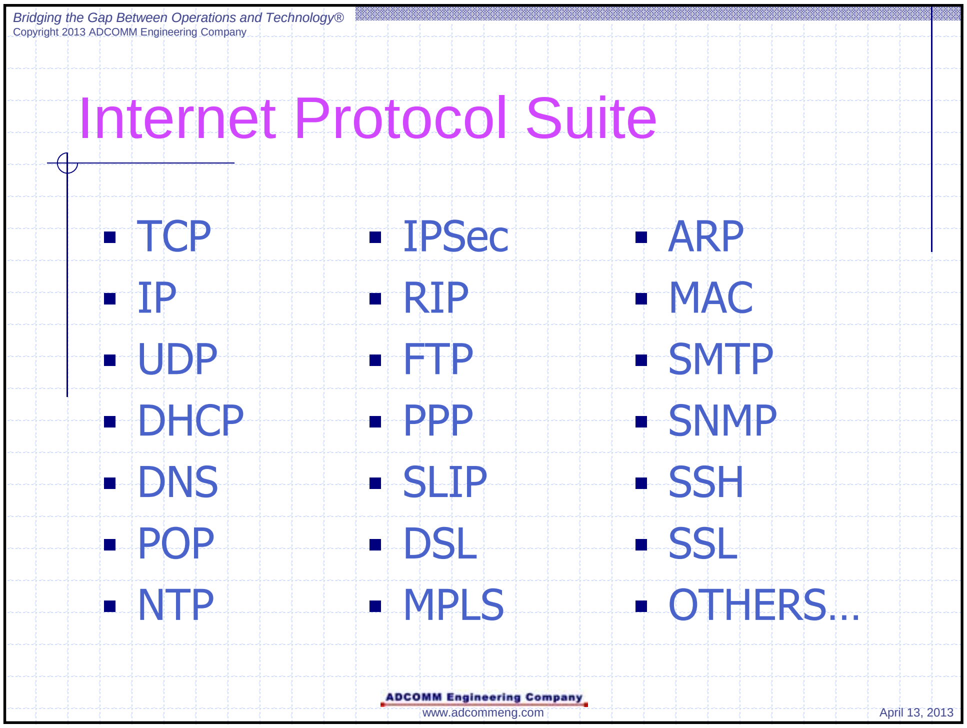

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Internet Protocol Suite

- TCP
- IP
- UDP
- DHCP
- DNS
- POP
- NTP
- IPSec
- RIP
- FTP
- PPP
- SLIP
- DSL
- MPLS
- ARP
- MAC
- SMTP
- SNMP
- SSH
- SSL
- OTHERS…

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Internet Protocol Suite

- DNS – Domain Name Service
- POP – Post Office Protocol (POP3)
- MPLS – Multiprotocol Label Switching
- ARP – Address Resolution Protocol
- SMTP – Simple Mail Transfer Protocol
- SNMP – Simple Network Management Protocol
- SSH – Secure Shell
- SSL – Secure Socket Layer
- HTTP & HTTPS – Hypertext Transfer Protocol (Secure)

TCP

- Reliable
- Provides error free reassembly of IP packets & related control
- Connection-oriented
- Layer 4 protocol

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UDP

- "Best Effort" – unreliable
- No error correction
- Great for streaming media, VoIP
- Connection-less oriented
- Layer 4 protocol

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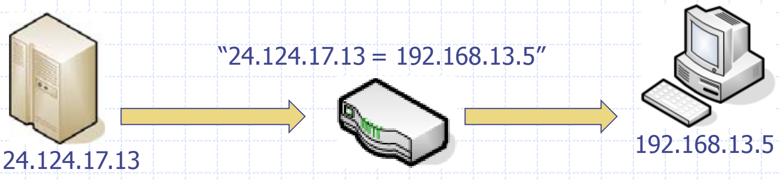
NAT

- Network Address Translation
- Attempt to resolve IPv4 address exhaustion
- Changes IP and other data in packet as it passes through router



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DHCP

- Dynamic Host Configuration Protocol
- "Obtain an IP address automatically" in Windows

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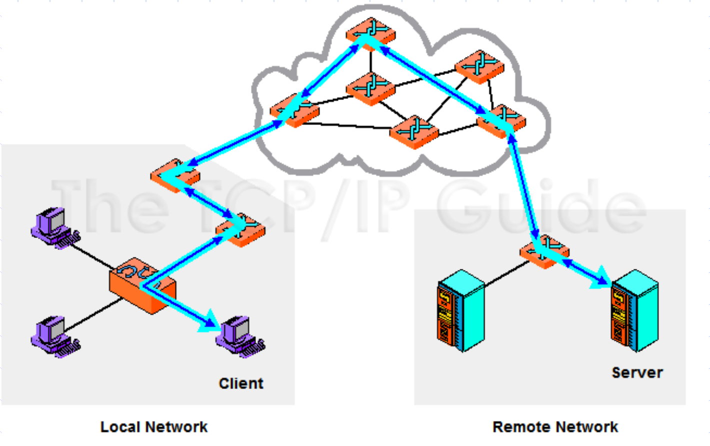
What is IP?

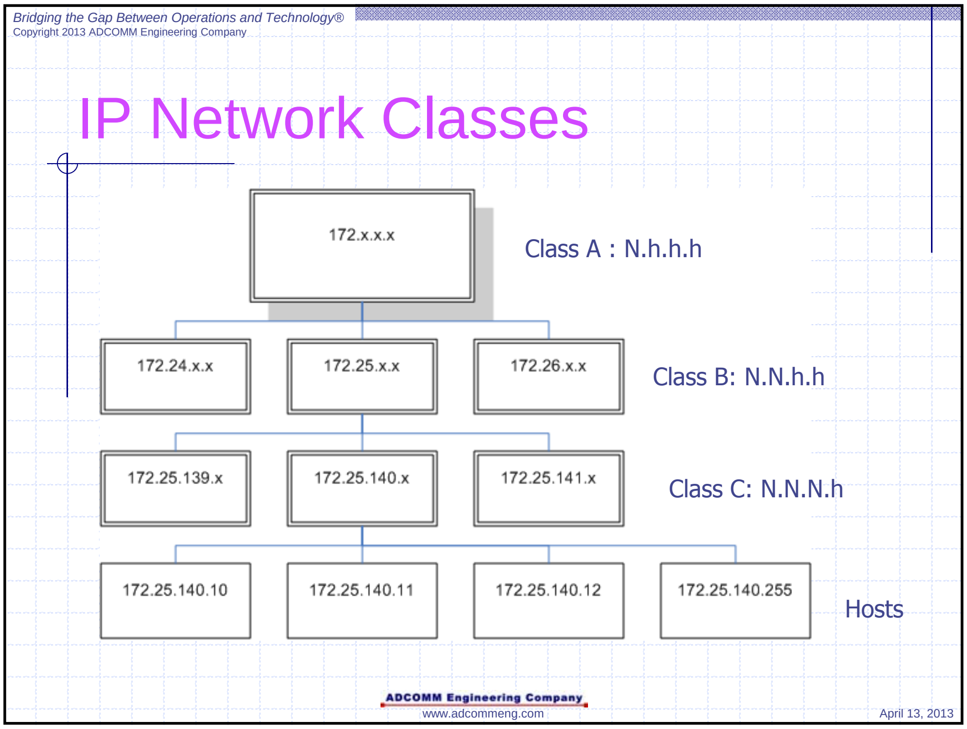


What is IP ?

- A numbering system used to describe networked devices uniquely within a domain
- (Version 4) 32 bit, divided into 4 "octets"
  - 194.25.140.12
- Describes "Networks" and "Hosts"

IP Addresses - Classful

- Network and Host:
  - N.N.N.h (Class C address)
    - 194.25.140.(0-255)
  - N.N.h.h (Class B address)
    - 129.25.(0-255).(0-255)
  - N.h.h.h (Class A address)
    - 116.(0-255).(0-255).(0-255)



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IP Network Classes

172.x.x.x

Class A : N.h.h.h

172.24.x.x
172.25.x.x
172.26.x.x

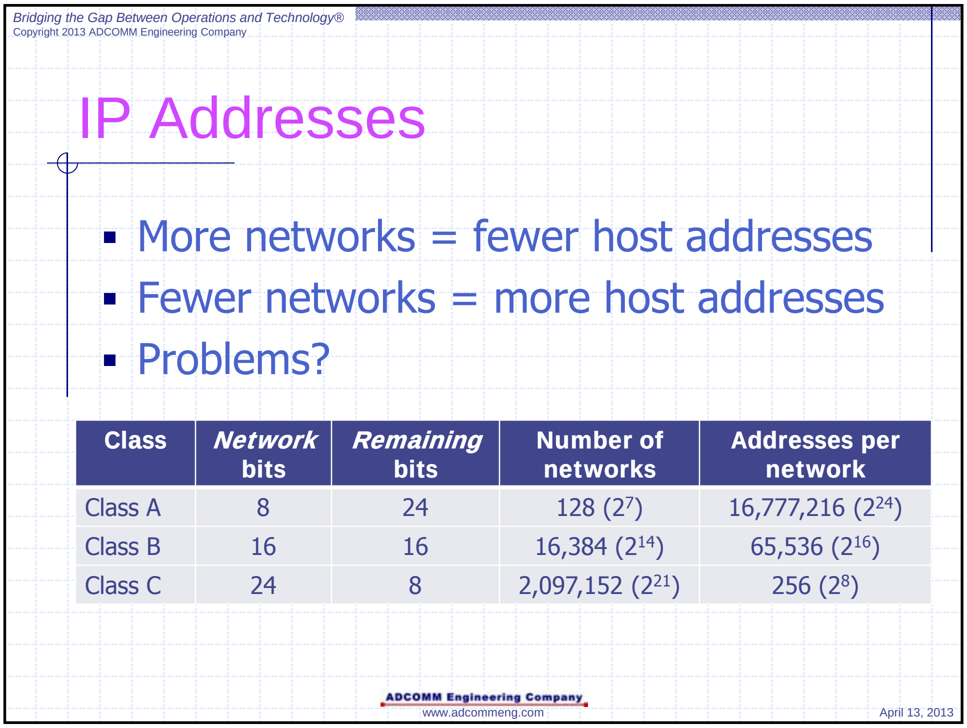
Class B: N.N.h.h

172.25.139.x
172.25.140.x
172.25.141.x

Class C: N.N.N.h

172.25.140.10
172.25.140.11
172.25.140.12
172.25.140.255

Hosts



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IP Addresses

- More networks = fewer host addresses
- Fewer networks = more host addresses
- Problems?

Class	*Network* bits	*Remaining* bits	Number of networks	Addresses per network
Class A	8	24	128 (2^7)	16,777,216 (2^{24})
Class B	16	16	16,384 (2^{14})	65,536 (2^{16})
Class C	24	8	2,097,152 (2^{21})	256 (2^8)

IP Addresses

- Classless Inter Domain Routing (CIDR)
  - Break out addressing anywhere
  - More flexibility
  - No huge jump in N vs h
- Combines IP address & Subnet Mask
- 192.13.10.0/24 indicates “range of network addresses from 192.13.10.0 through 192.13.10.255”

IP Versions

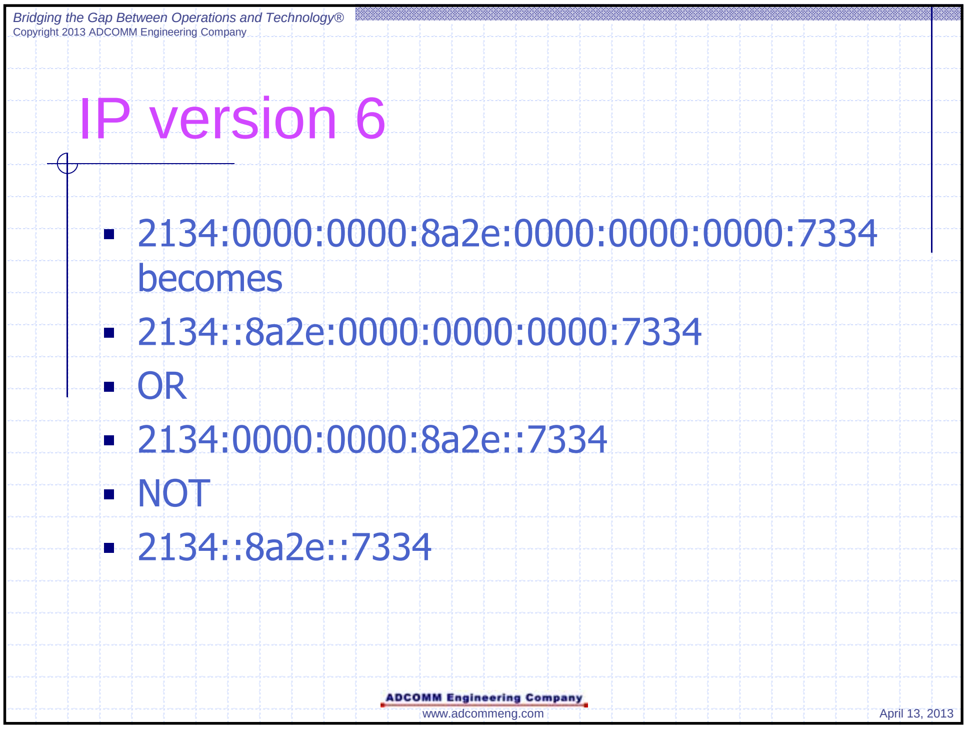
- IPv4
  - 4 billion address (4.3 x 10^9)
  - 32 bit addressing (4 octets)
- IPv6
  - 128 bit addressing (8 hextets)
  - 340 undecillion, or 3.4×10^38 addresses

IP Version 6

- 8 groups of 4 hexadecimal digits separated by colons
- 2001:0db8:85a3:0000:0000:8a2e:0370:7334
- Abbreviation rules:
  - – Drop leading 0's in a 16 bit digit
  - – Single consecutive 0 groups replaced by ::
  - – Can't use :: twice in one address

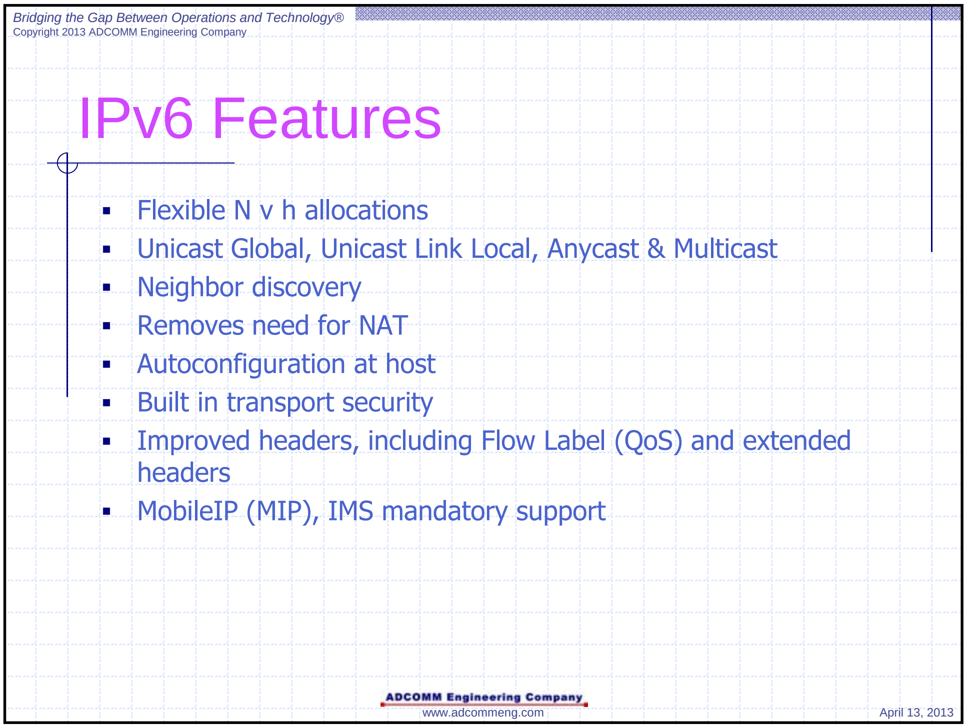
IP Version 6

- 2001:0db8:85a3:0000:0000:8a2e:0370:7334 becomes
- 2001:db8:85a3:0000:0000:8a2e:370:7334 (drop leading 0's) or
- 2001:0db8:85a3::8a2e:0370:7334 (groups of 0's replaced by colons)
- 2001:db8:85a3::8a2e:370:7334 (both)



IP version 6

- 2134:0000:0000:8a2e:0000:0000:0000:7334 becomes
- 2134::8a2e:0000:0000:0000:7334
- OR
- 2134:0000:0000:8a2e::7334
- NOT
- 2134::8a2e::7334



IPv6 Features

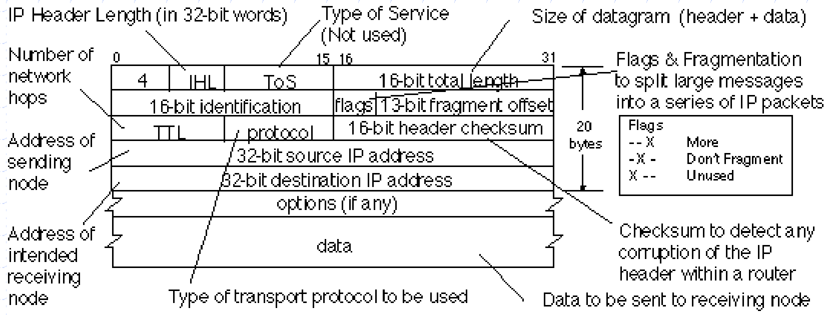
- Flexible N v h allocations
- Unicast Global, Unicast Link Local, Anycast & Multicast
- Neighbor discovery
- Removes need for NAT
- Autoconfiguration at host
- Built in transport security
- Improved headers, including Flow Label (QoS) and extended headers
- MobileIP (MIP), IMS mandatory support

IPv4 to IPv6 Transitions

- Dual Stack: hardware runs IPv4 & IPv6 both
- Tunneling: One protocol goes inside the other
- Network Address Translation – Protocol Translation (NAT-PT): translates one to the other

---

IP Packet Header


IP Header Length (in 32-bit words)
Type of Service (Not used)
Size of datagram (header + data)
Number of network hops
0
15
16
31
4
IHL
ToS
16-bit total length
16-bit identification
flags
13-bit fragment offset
TTL
protocol
16-bit header checksum
32-bit source IP address
32-bit destination IP address
options (if any)
data
20 bytes
Flags & Fragmentation to split large messages into a series of IP packets
Flags
-- X More
-X - Don't Fragment
X -- Unused
Address of sending node
Address of intended receiving node
Checksum to detect any corruption of the IP header within a router
Type of transport protocol to be used
Data to be sent to receiving node

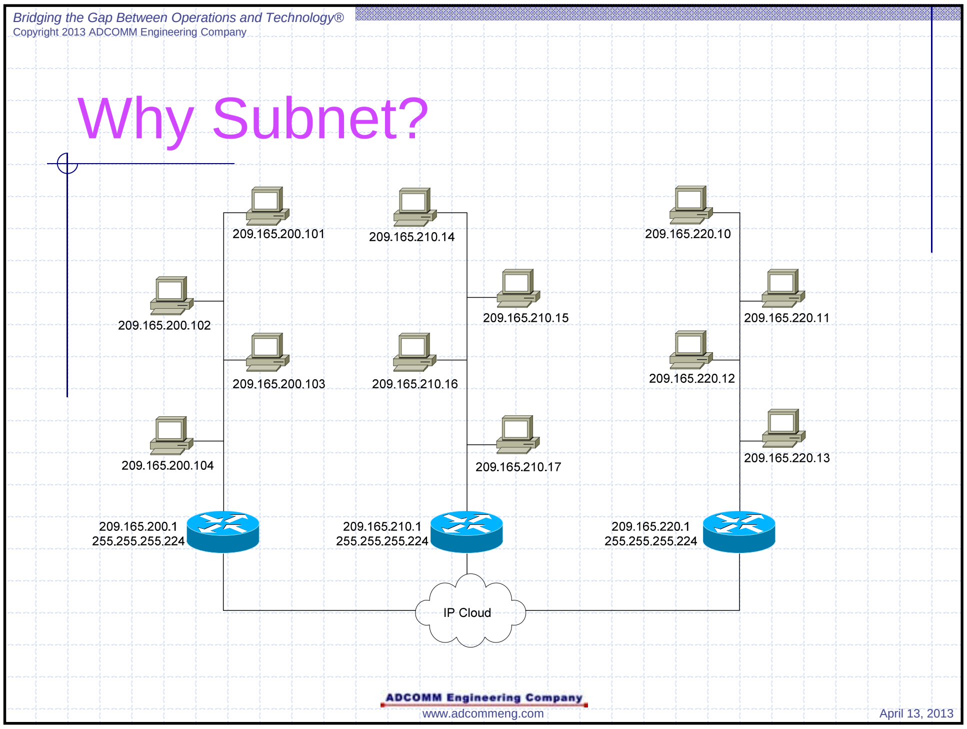
Class breakdown

Class	Leading bits	Start	End	CIDR suffix	Default subnet mask
Class A	0	0.0.0.0	127.255.255.255	/8	255.0.0.0
Class B	10	128.0.0.0	191.255.255.255	/16	255.255.0.0
Class C	110	192.0.0.0	223.255.255.255	/24	255.255.255.0
Class D (multicast)	1110	224.0.0.0	239.255.255.255	/4	not defined
Class E (reserved)	1111	240.0.0.0	255.255.255.255	/4	not defined

---

Subnetting: Why you care

- Subnets define what is IN your network and what is OUT
- Addresses in network are handled locally
- Addresses out of network are sent to a “gateway”
- Common place to screw up network



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Why Subnet?

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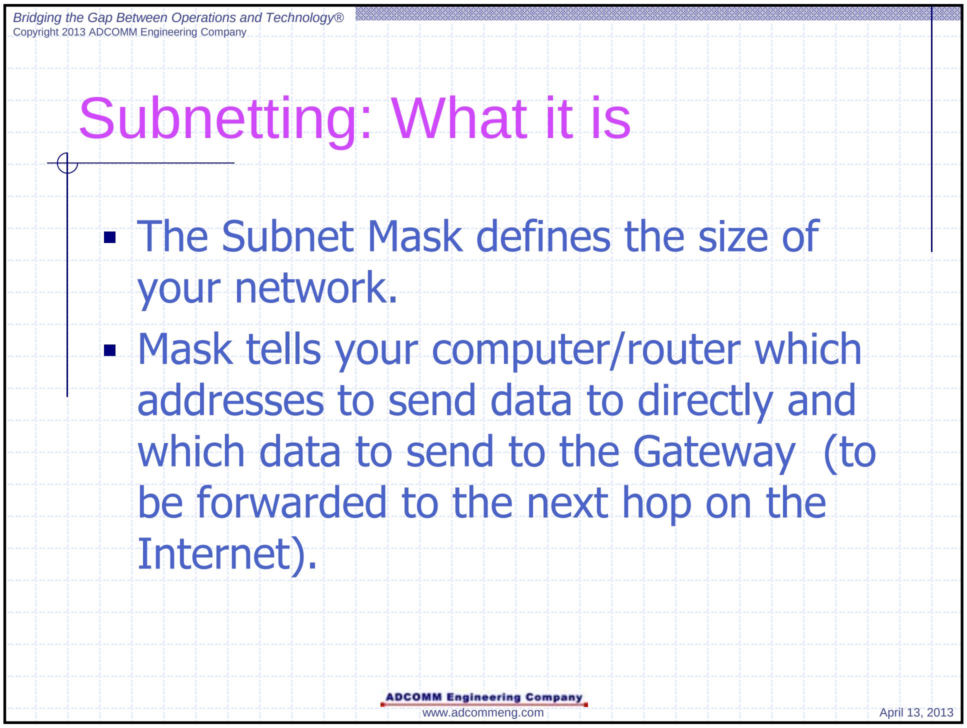

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Subnetting: What it is

- The Subnet Mask defines the size of your network.
- Mask tells your computer/router which addresses to send data to directly and which data to send to the Gateway (to be forwarded to the next hop on the Internet).

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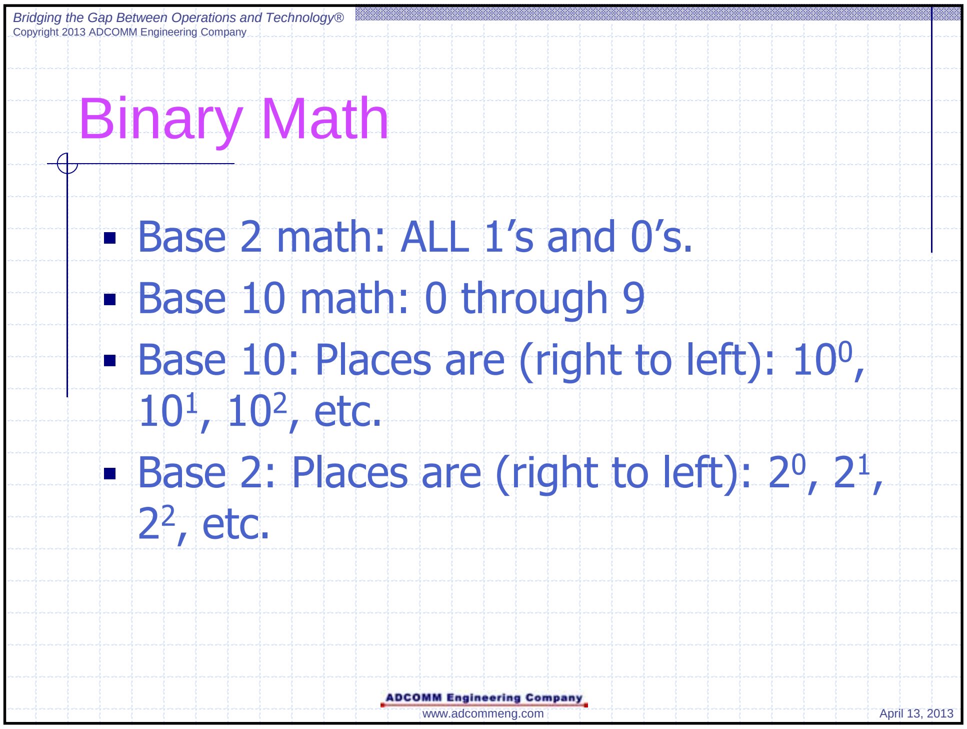

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Binary Math

- Base 2 math: ALL 1's and 0's.
- Base 10 math: 0 through 9
- Base 10: Places are (right to left): 10^0, 10^1, 10^2, etc.
- Base 2: Places are (right to left): 2^0, 2^1, 2^2, etc.

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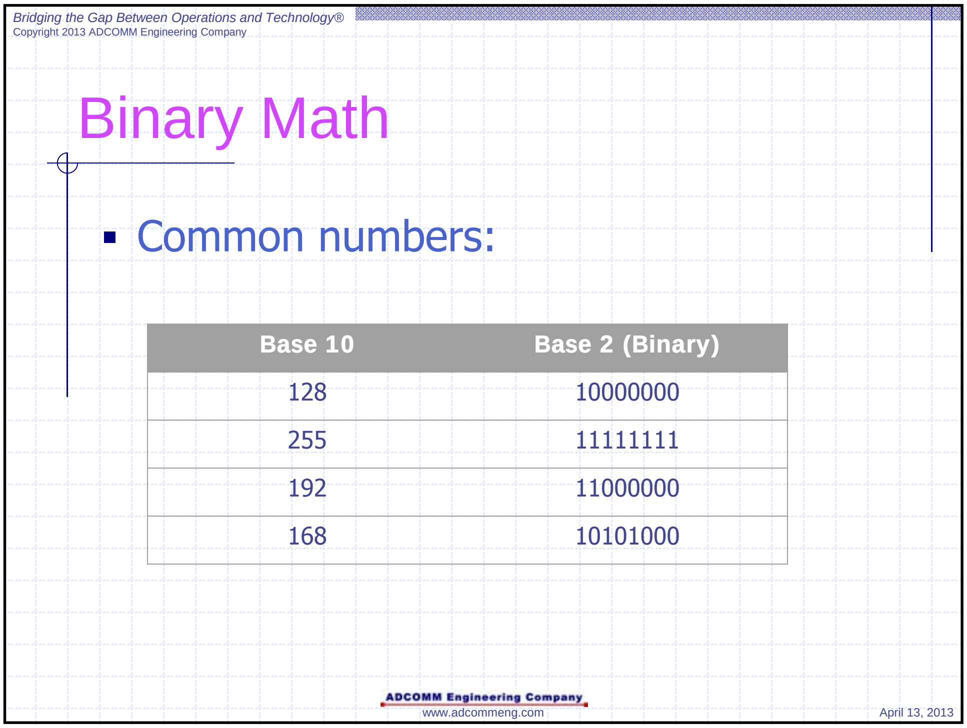

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Binary Math

- Common numbers:

Base 10	Base 2 (Binary)
128	10000000
255	11111111
192	11000000
168	10101000

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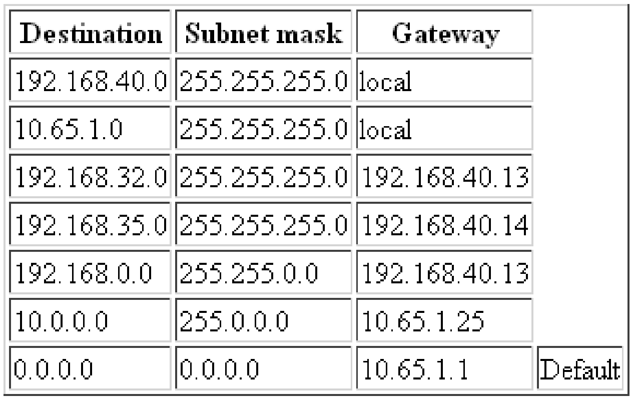
Routing Table



Destination	Subnet mask	Gateway	
192.168.40.0	255.255.255.0	local	
10.65.1.0	255.255.255.0	local	
192.168.32.0	255.255.255.0	192.168.40.13	
192.168.35.0	255.255.255.0	192.168.40.14	
192.168.0.0	255.255.0.0	192.168.40.13	
10.0.0.0	255.0.0.0	10.65.1.25	
0.0.0.0	0.0.0.0	10.65.1.1	Default

Subnetting

- By comparing a subnet mask with an IP address, systems can determine which portion of the IP address relates to the network, and which portion relates to the host.
- Logical AND

	0	1
0	0	0
1	0	1

Subnet Mask

255.255.255.0 11111111.11111111.11111111.00000000

192.168.40.12 **11000000.10101000.00101000.00000000**

192.168.40.0

	0	1
0	0	0
1	0	1

Practical IP

- Broken? Do this:
  - Check IP addresses on end & intermediate devices
  - Check subnet masking
- Tools:
  - http://www.subnet-calculator.com/
  - http://www.tcpipguide.com/
  - Netstat –r command
  - Router print

Security

- Firewalls
- Encryption
  - Data and transport
- IPSec
- Physical security
- Administrative controls

IP Exploits

- "Spoofing"
- MITM attacks
- DoS Attacks
  - Ping attacks
    - Smurf/Fraggle (ICMP Echo)
  - DDoS delivery methods
- DNS oriented attacks
- ICMP tunneling

Security Resources

- "Security Now" podcast, Steve Gibson & Leo Laporte
- Schneier on Security: http://www.schneier.com
- Dark Reading

  http://www.darkreading.com
- The TCP/IP Guide

  http://www.tcpipguide.com/

Questions?

ADCOMM Engineering Co
Dave Magnenat, PMP
D.magnenat@adcomm911.com
360-377-4657

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Wireless Local Area Networks

What you need to know

Communications Academy 2013

Scott Peabody, PE

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WLAN: What you need to know

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Pop Quiz

How many WiFi standards are there?

a. One : 802.11-2012
b. Three: 802.11b/g/n
c. Four: 802.11a/b/g/n
d. Twenty eight: 802.11a/b/c/d/e/g/h/i/j/k/m/n/p/r/s/u/w/x/y/z/aa/ac/ad/ae/af/ah/ai

a. There is only one official standard 802.11-2012. It incorporated all approved amendments. The term standard is commonly used for the amendments which are designated by lower case letters.

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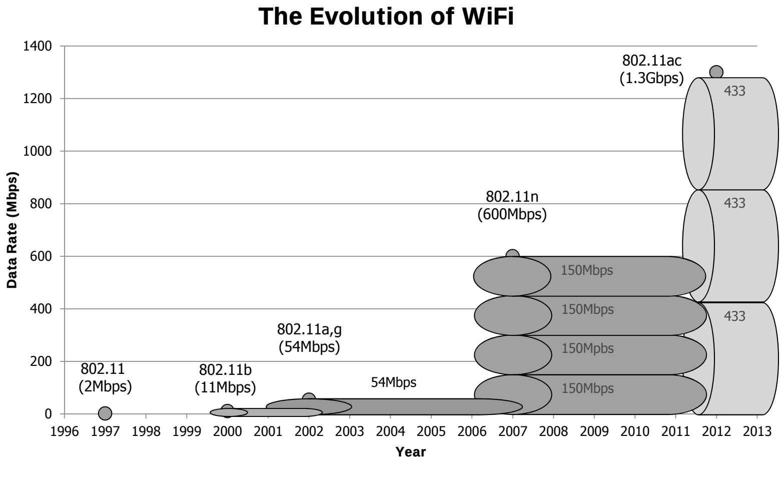
WiFi Timeline



The Evolution of WiFi

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How did they get more speed?

2.4 GHz

- 802.11b/g
  - 20 MHz channel width
  - 3 non-overlapping channels
  - 802.11b: 11 Mbps
  - 802.11g: 54 Mbps

5.8 GHz

- 802.11a
  - 20 MHz channel width
  - 20 non-overlapping channels
  - More bits per Hertz
  - 802.11a: 54 Mbps

2.4 and 5.8 GHz

- 802.11n
  - 20 or 40 MHz channels
  - Still more bits per Hertz
  - Up to "4 x 4" MIMO

5.8 GHz

- 802.11ac
  - 20, 40, 80 or 160 MHz chs.
  - Many more bits per Hertz
  - Up to "8 x 8" MIMO

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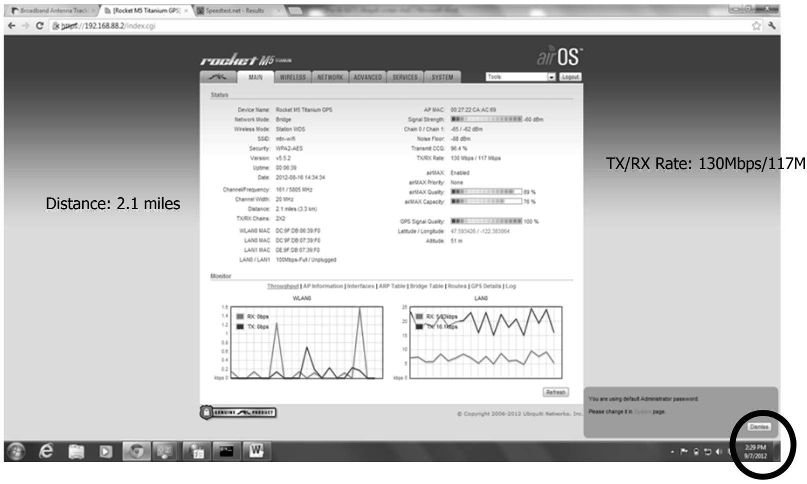
What is MIMO?

MIMO: Multiple Input Multiple Output

- 802.11n and 802.11ac can simultaneously use multiple antennas
  - Space-Time Block Coding (STBC): Sends outgoing data redundantly through multiple antennas
  - Spatial Multiplexing (SM): Split outgoing data into multiple streams transmitted through multiple antennas
  - Transmit Beamforming (TxBF): Steers an outgoing stream toward the receiver to improve received signal strength

Actual Field Results



Status

Device Name: Rocket M5 Titanium GPS
Network Mode: Bridge
Wireless Mode: Station WDS
SSID: mtn-wifi
Security: WPA2-AES
Version: v5.5.2
Uptime: 00:06:39
Date: 2012-08-16 14:34:34
Channel/Frequency: 161 / 5805 MHz
Channel Width: 20 MHz
Distance: 2.1 miles (3.3 km)
TX/RX Chains: 2X2
WLAN0 MAC: DC:9F:DB:06:39:F0
LAN0 MAC: DC:9F:DB:07:39:F0
LAN1 MAC: DE:9F:DB:07:39:F0
LAN0 / LAN1: 100Mbps-Full / Unplugged

AP MAC: 00:27:22:CA:AC:69
Signal Strength: -60 dBm
Chain 0 / Chain 1: -65 / -62 dBm
Noise Floor: -88 dBm
Transmit CCQ: 96.4 %
TX/RX Rate: 130 Mbps / 117 Mbps
airMAX: Enabled
airMAX Priority: None
airMAX Quality: 89 %
airMAX Capacity: 76 %
GPS Signal Quality: 100 %
Latitude / Longitude: 47.593426 / -122.383064
Altitude: 51 m

Monitor

Throughput | AP Information | Interfaces | ARP Table | Bridge Table | Routes | GPS Details | Log

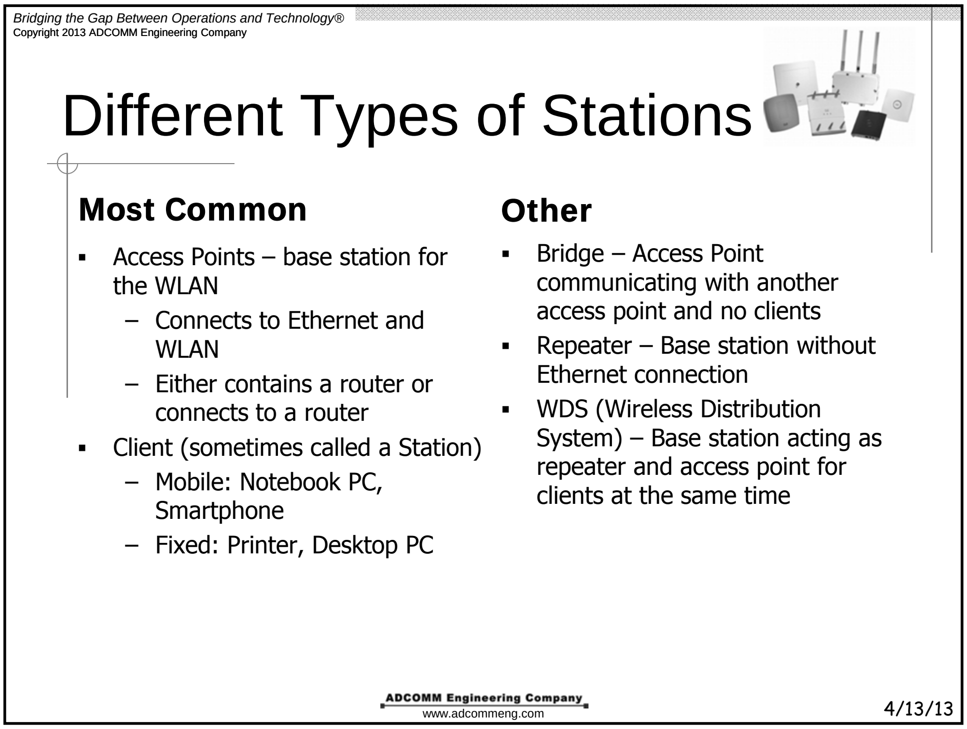
You are using default Administrator password. Please change it in System page.

Distance: 2.1 miles

TX/RX Rate: 130Mbps/117Mbps

Choices, Choices, Choices

- Different types of Stations
- Different sources of power
- Different antennas
- Many vendors



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Different Types of Stations

Most Common

- Access Points – base station for the WLAN
  - Connects to Ethernet and WLAN
  - Either contains a router or connects to a router
- Client (sometimes called a Station)
  - Mobile: Notebook PC, Smartphone
  - Fixed: Printer, Desktop PC

Other

- Bridge – Access Point communicating with another access point and no clients
- Repeater – Base station without Ethernet connection
- WDS (Wireless Distribution System) – Base station acting as repeater and access point for clients at the same time

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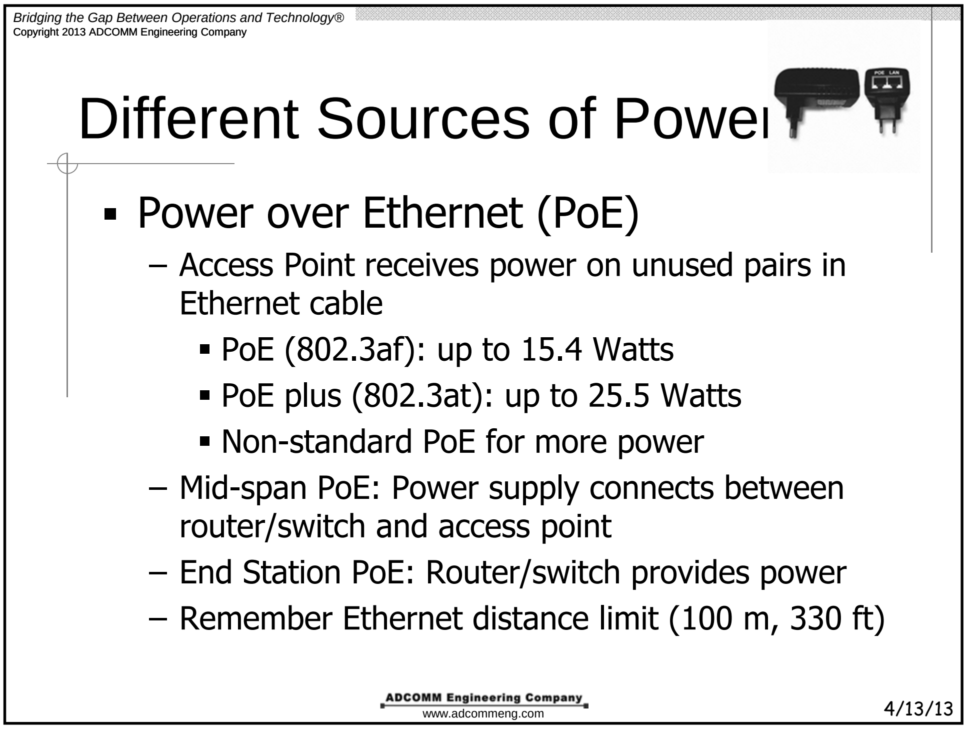

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Different Sources of Power

- Power over Ethernet (PoE)
  - Access Point receives power on unused pairs in Ethernet cable
    - PoE (802.3af): up to 15.4 Watts
    - PoE plus (802.3at): up to 25.5 Watts
    - Non-standard PoE for more power
  - Mid-span PoE: Power supply connects between router/switch and access point
  - End Station PoE: Router/switch provides power
  - Remember Ethernet distance limit (100 m, 330 ft)

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Different Types of Antennas

- Omnidirectional: lower gain, 360° pattern
- Directional sector: higher gain, 90° or 120° pattern
- Directional dish: highest gain, narrow beam
- Beamforming array: dynamic pattern
- Tracking antenna: directional antenna with a GPS based controller and positioner

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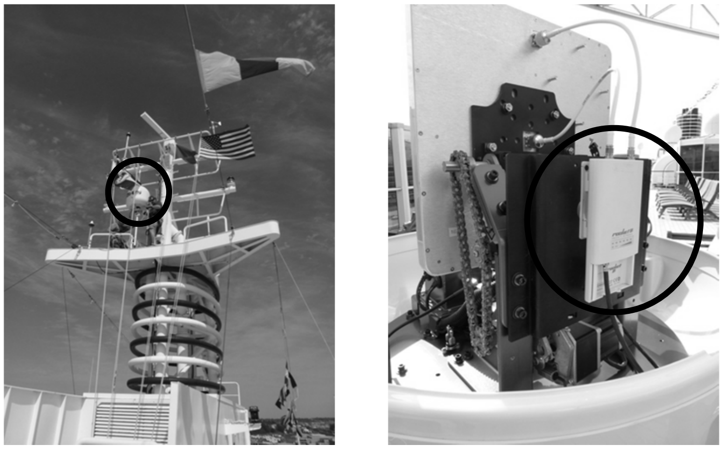
Tracking Antenna and Radio



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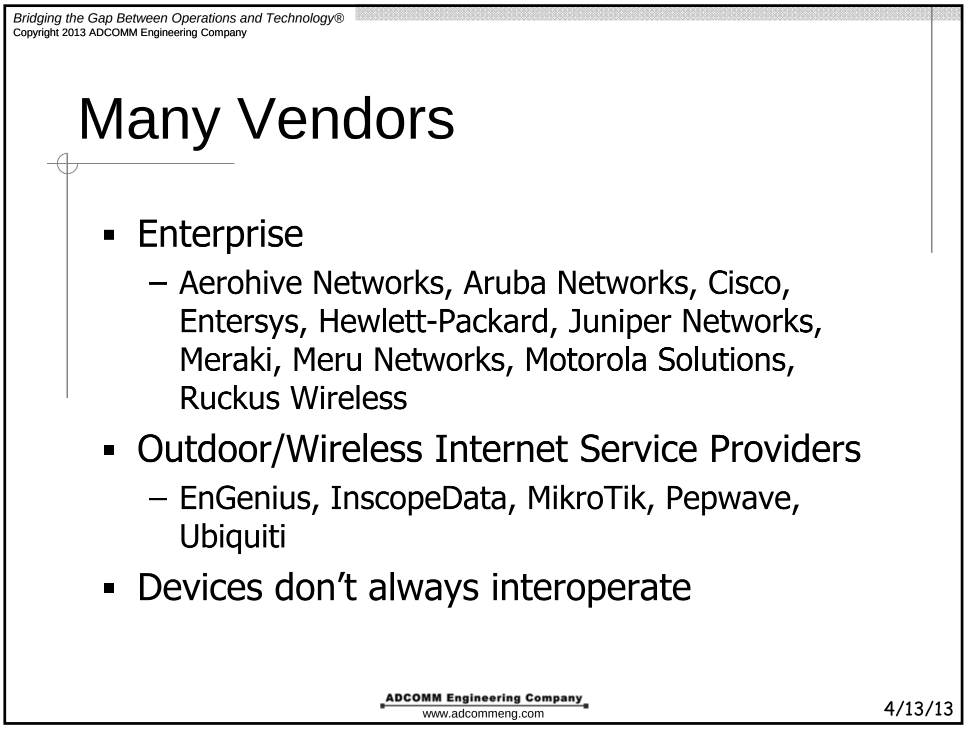

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Many Vendors

- Enterprise
  - Aerohive Networks, Aruba Networks, Cisco, Entersys, Hewlett-Packard, Juniper Networks, Meraki, Meru Networks, Motorola Solutions, Ruckus Wireless
- Outdoor/Wireless Internet Service Providers
  - EnGenius, InscopeData, MikroTik, Pepwave, Ubiquiti
- Devices don’t always interoperate

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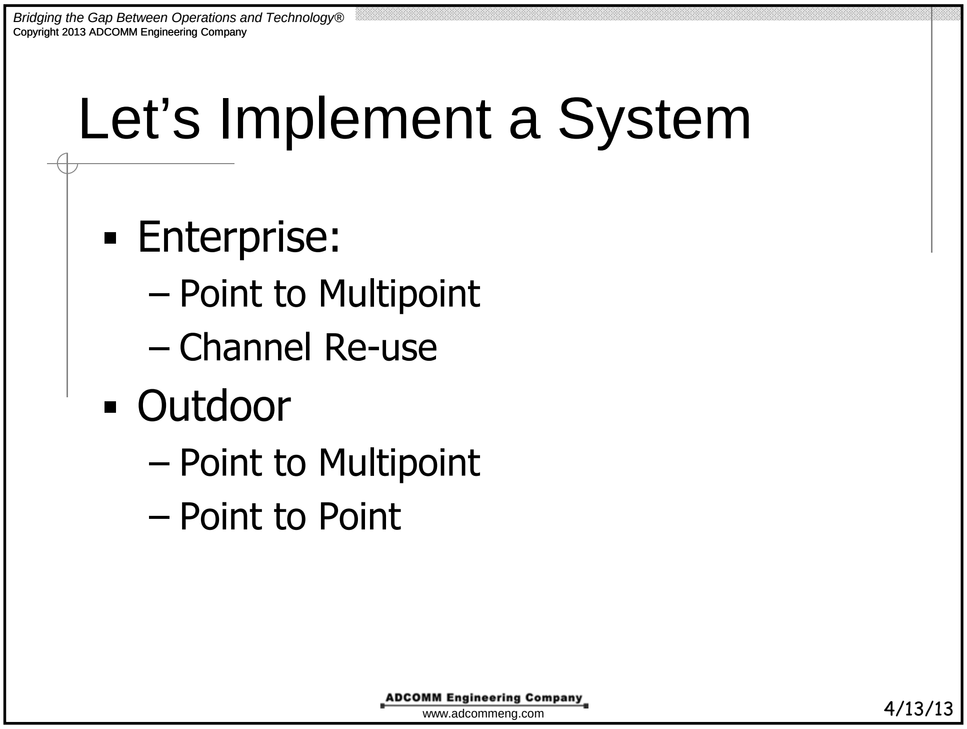

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Let’s Implement a System

- Enterprise:
  - Point to Multipoint
  - Channel Re-use
- Outdoor
  - Point to Multipoint
  - Point to Point

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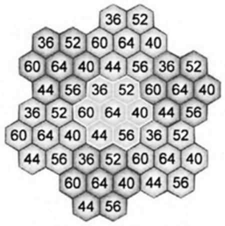
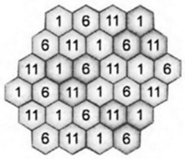
Enterprise

- Point to Multipoint
- Many omnidirectional access points require frequency planning



7-to-1 Reuse pattern for 5GHz using 20MHz channels



3-to-1 Reuse pattern for 2GHz using 20MHz channels

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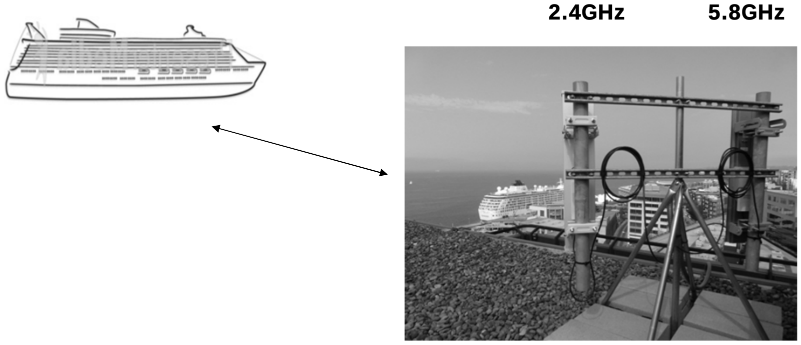
Outdoor Point to Multipoint

Directional Access Points
2.4GHz 5.8GHz



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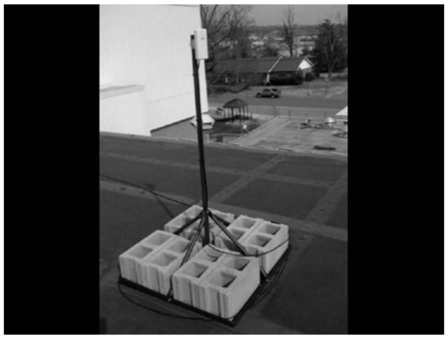
Outdoor Point to Point

- Roof mount
- Small inexpensive radio and antenna unit



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WLAN: Another Threat to Security

- Security Measures
  - – Hide SSID
  - – MAC ID filtering
  - – Static ip addressing
- 802.11 Encryption

WEP (Wireless Encryption Protocol)	Obsolete, don't use it
WPA (WiFi Protected Access)	Disables speeds above 54Mbps in 802.11n
WPA2 (WPA version 2)	Recommended

WPA and WPA2 have two modes:
- Personal – Requires Pre-Shared Key (PSK)
- Enterprise – Requires Radius Server

Questions?

Thank you!

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Hands-On IP for Radio Technicians

Network Troubleshooting

Communications Academy 2013
Joe Blaschka Jr., PE

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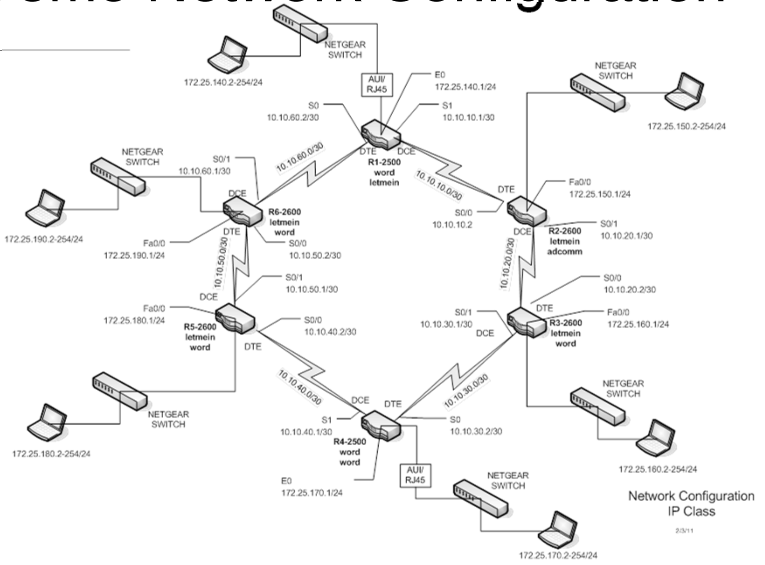
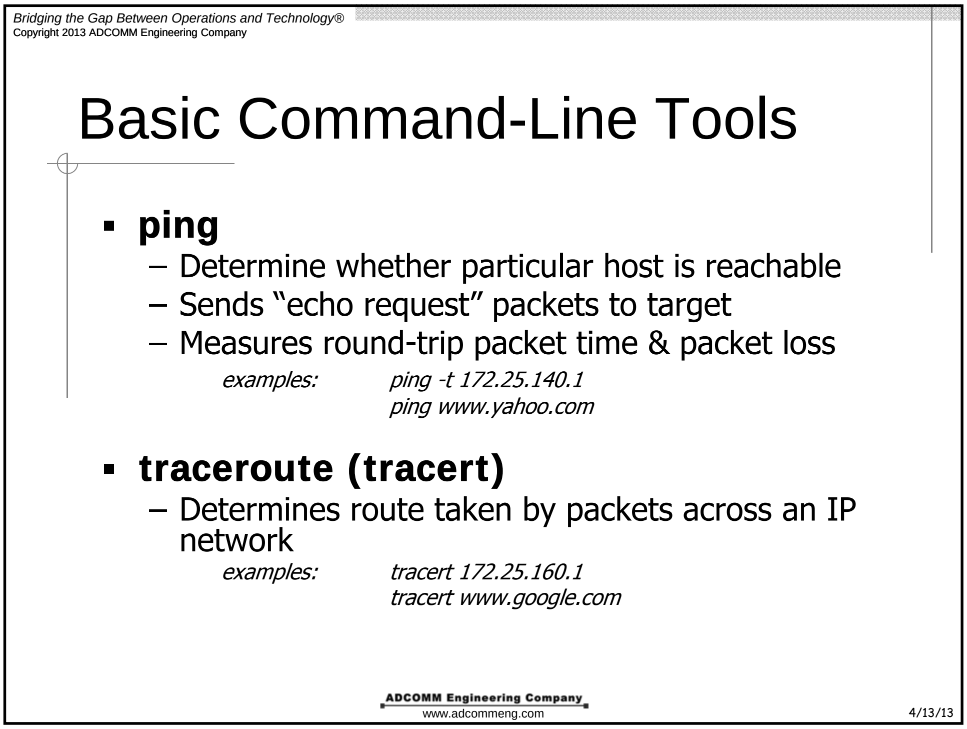
Demo Network Configuration





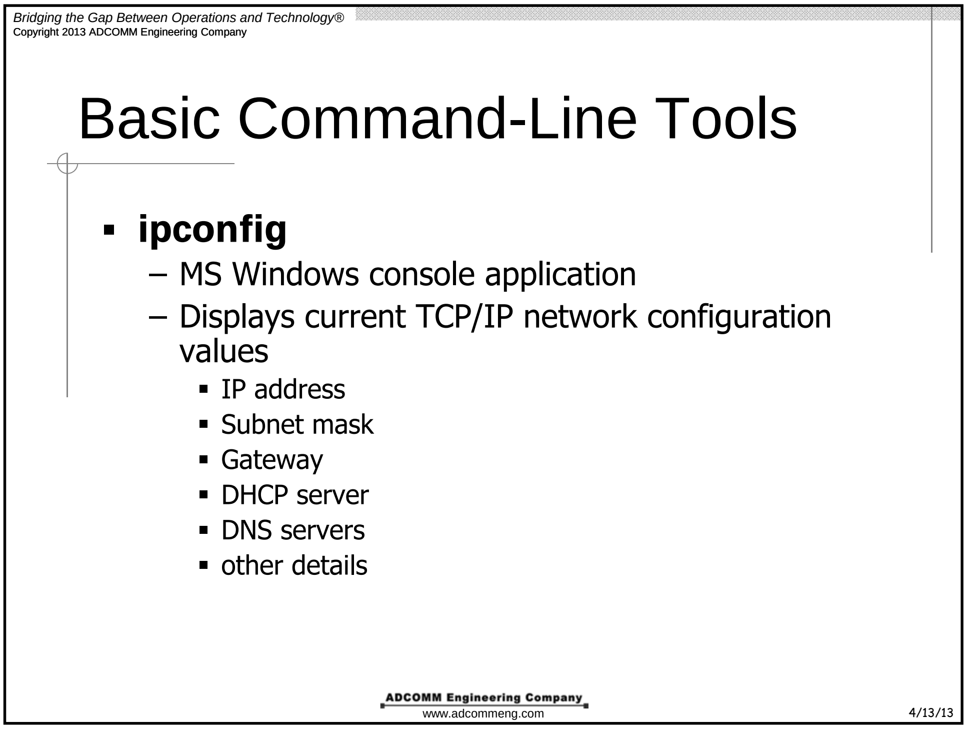
Basic Command-Line Tools

- **ping**
  - – Determine whether particular host is reachable
  - – Sends "echo request" packets to target
  - – Measures round-trip packet time & packet loss

examples: *ping -t 172.25.140.1*
ping www.yahoo.com

- **traceroute (tracert)**
  - – Determines route taken by packets across an IP network

examples: *tracert 172.25.160.1*
tracert www.google.com



Basic Command-Line Tools

- **ipconfig**
  - – MS Windows console application
  - – Displays current TCP/IP network configuration values
    - IP address
    - Subnet mask
    - Gateway
    - DHCP server
    - DNS servers
    - other details

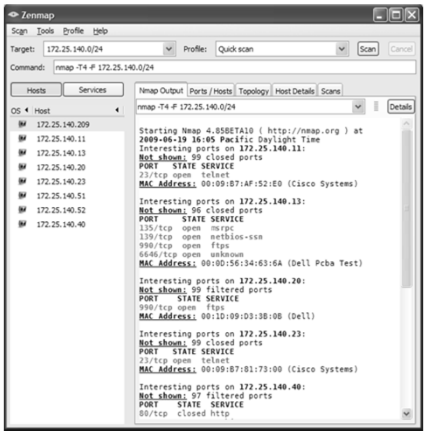
Basic Command-Line Tools

- **telnet**
  - Interactive remote login tool
  - Generally used to access a command line interface on a remote host (or device)
  - Default TCP port 23

    example: *telnet 172.25.140.50*
- **netstat -r**
  - Display PC routing table

Windows Tools

- **NMAP/Zenmap**
  - "Network Mapper"
  - Network exploration tool
  - Identifies Hosts & Running Services
  - TCP/UDP port scanner
  - NMAP: command line
  - Zenmap: GUI



Target: 172.25.140.0/24

Profile: Quick scan

Command: nmap -T4 -F 172.25.140.0/24

172.25.140.209
172.25.140.11
172.25.140.13
172.25.140.20
172.25.140.23
172.25.140.51
172.25.140.52
172.25.140.40

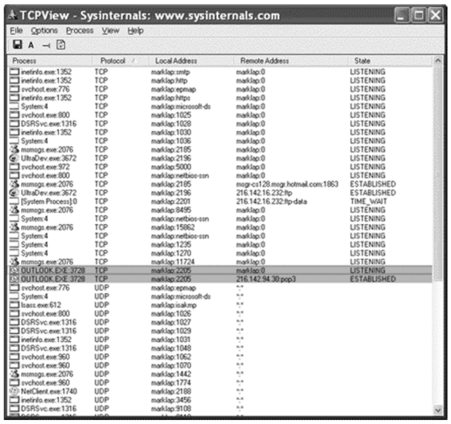
nmap -T4 -F 172.25.140.0/24

```
Starting Nmap 4.85BETA10 ( http://nmap.org ) at
2009-06-19 16:05 Pacific Daylight Time
Interesting ports on 172.25.140.11:
Not shown: 99 closed ports
PORT   STATE SERVICE
23/tcp open  telnet
MAC Address: 00:09:B7:AF:52:E0 (Cisco Systems)

Interesting ports on 172.25.140.13:
Not shown: 96 closed ports
PORT     STATE SERVICE
135/tcp  open  msrpc
139/tcp  open  netbios-ssn
990/tcp  open  ftps
6646/tcp open  unknown
MAC Address: 00:0D:56:34:63:6A (Dell Pcba Test)

Interesting ports on 172.25.140.20:
Not shown: 99 filtered ports
PORT    STATE SERVICE
990/tcp open  ftps
MAC Address: 00:1D:09:D3:3B:0B (Dell)

Interesting ports on 172.25.140.23:
Not shown: 99 closed ports
PORT   STATE SERVICE
23/tcp open  telnet
MAC Address: 00:09:B7:81:73:00 (Cisco Systems)

Interesting ports on 172.25.140.40:
Not shown: 97 filtered ports
PORT    STATE  SERVICE
80/tcp  closed http
```

http://nmap.org

Windows Tools

- **TCPView**
  - Lists all TCP & UDP port endpoints on a PC
  - Similar to *netstat* command in Unix and Windows



Process	Protocol	Local Address	Remote Address	State
inetinfo.exe:1352	TCP	marklap:smtp	marklap:0	LISTENING
inetinfo.exe:1352	TCP	marklap:http	marklap:0	LISTENING
svchost.exe:776	TCP	marklap:epmap	marklap:0	LISTENING
inetinfo.exe:1352	TCP	marklap:https	marklap:0	LISTENING
System:4	TCP	marklap:microsoft-ds	marklap:0	LISTENING
svchost.exe:800	TCP	marklap:1025	marklap:0	LISTENING
DSRSvc.exe:1316	TCP	marklap:1028	marklap:0	LISTENING
inetinfo.exe:1352	TCP	marklap:1030	marklap:0	LISTENING
System:4	TCP	marklap:1036	marklap:0	LISTENING
msmsgs.exe:2076	TCP	marklap:2185	marklap:0	LISTENING
UltraDev.exe:3672	TCP	marklap:2196	marklap:0	LISTENING
svchost.exe:972	TCP	marklap:5000	marklap:0	LISTENING
svchost.exe:800	TCP	marklap:netbios-ssn	marklap:0	LISTENING
msmsgs.exe:2076	TCP	marklap:2185	msgr-cs128.msgr.hotmail.com:1863	ESTABLISHED
UltraDev.exe:3672	TCP	marklap:2196	216.142.16.232:ftp	ESTABLISHED
[System Process]:0	TCP	marklap:2201	216.142.16.232:ftp-data	TIME_WAIT
msmsgs.exe:2076	TCP	marklap:8495	marklap:0	LISTENING
System:4	TCP	marklap:netbios-ssn	marklap:0	LISTENING
msmsgs.exe:2076	TCP	marklap:15862	marklap:0	LISTENING
System:4	TCP	marklap:netbios-ssn	marklap:0	LISTENING
System:4	TCP	marklap:1235	marklap:0	LISTENING
System:4	TCP	marklap:1270	marklap:0	LISTENING
msmsgs.exe:2076	TCP	marklap:11724	marklap:0	LISTENING
OUTLOOK.EXE:3728	TCP	marklap:2205	marklap:0	LISTENING
OUTLOOK.EXE:3728	TCP	marklap:2205	216.142.94.30:pop3	ESTABLISHED
svchost.exe:776	UDP	marklap:epmap	*:*	
System:4	UDP	marklap:microsoft-ds	*:*	
lsass.exe:612	UDP	marklap:isakmp	*:*	
svchost.exe:800	UDP	marklap:1026	*:*	
DSRSvc.exe:1316	UDP	marklap:1027	*:*	
DSRSvc.exe:1316	UDP	marklap:1029	*:*	
inetinfo.exe:1352	UDP	marklap:1031	*:*	
DSRSvc.exe:1316	UDP	marklap:1048	*:*	
svchost.exe:960	UDP	marklap:1062	*:*	
svchost.exe:960	UDP	marklap:1070	*:*	
msmsgs.exe:2076	UDP	marklap:1442	*:*	
svchost.exe:960	UDP	marklap:1774	*:*	
NetClient.exe:1740	UDP	marklap:2188	*:*	
inetinfo.exe:1352	UDP	marklap:3456	*:*	
DSRSvc.exe:1316	UDP	marklap:9108	*:*	

http://technet.microsoft.com/en-us/sysinternals/bb897437.aspx

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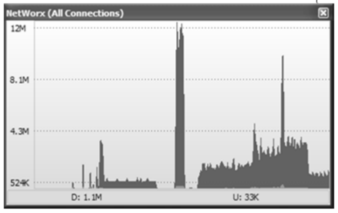
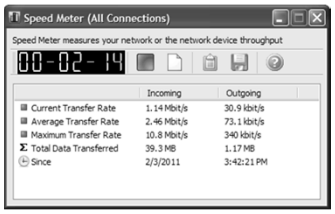
Windows Tools

- **Networx**
  - Live monitoring of incoming & outgoing TCP/IP bandwidth
  - Also built-in ping, traceroute, netstat, and other advanced features
  - Free MS Windows application
  - See also: Windows 8/7/Vista *Resource Monitor*





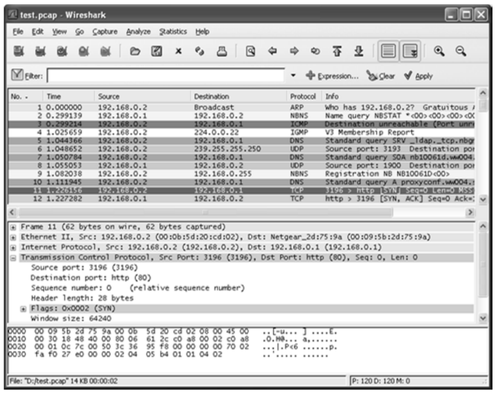
Speed Meter measures your network or the network device throughput

	Incoming	Outgoing
Current Transfer Rate	1.14 Mbit/s	30.9 kbit/s
Average Transfer Rate	2.46 Mbit/s	73.1 kbit/s
Maximum Transfer Rate	10.8 Mbit/s	340 kbit/s
Σ Total Data Transferred	39.3 MB	1.17 MB
Since	2/3/2011	3:42:21 PM

http://www.softperfect.com/products/networx/

Advanced Tools

- **Wireshark**
  - "Deep packet inspection"
  - Network protocol analyzer

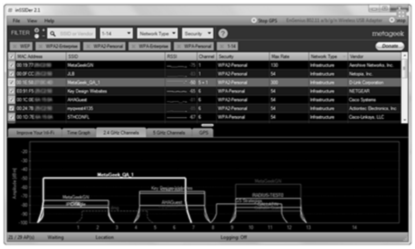

test.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply

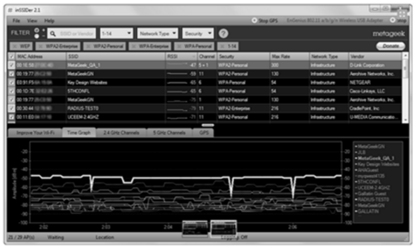
```
No. .  Time        Source         Destination       Protocol  Info
     1 0.000000    192.168.0.2    Broadcast         ARP       Who has 192.168.0.2?  Gratuitous 
     2 0.299139    192.168.0.1    192.168.0.2       NBNS      Name query NBSTAT *<00><00><00><0
     3 0.299214    192.168.0.2    192.168.0.1       ICMP      Destination unreachable (Port unr
     4 1.025659    192.168.0.2    224.0.0.22        IGMP      V3 Membership Report
     5 1.044366    192.168.0.2    192.168.0.1       DNS       Standard query SRV _ldap._tcp.nbg
     6 1.048652    192.168.0.2    239.255.255.250   UDP       Source port: 3193  Destination po
     7 1.050784    192.168.0.2    192.168.0.1       DNS       Standard query SOA nb10061d.ww004.
     8 1.055053    192.168.0.1    192.168.0.2       UDP       Source port: 1900  Destination po
     9 1.082038    192.168.0.2    192.168.0.255     NBNS      Registration NB NB10061D<00>
    10 1.111945    192.168.0.2    192.168.0.1       DNS       Standard query A proxyconf.ww004.
    11 1.226156    192.168.0.2    192.168.0.1       TCP       3196 > http [SYN] Seq=0 Len=0 MSS
    12 1.227282    192.168.0.1    192.168.0.2       TCP       http > 3196 [SYN, ACK] Seq=0 Ack=

⊞ Frame 11 (62 bytes on wire, 62 bytes captured)
⊞ Ethernet II, Src: 192.168.0.2 (00:0b:5d:20:cd:02), Dst: Netgear_2d:75:9a (00:09:5b:2d:75:9a)
⊞ Internet Protocol, Src: 192.168.0.2 (192.168.0.2), Dst: 192.168.0.1 (192.168.0.1)
⊟ Transmission Control Protocol, Src Port: 3196 (3196), Dst Port: http (80), Seq: 0, Len: 0
    Source port: 3196 (3196)
    Destination port: http (80)
    Sequence number: 0    (relative sequence number)
    Header length: 28 bytes
  ⊞ Flags: 0x0002 (SYN)
    Window size: 64240

0000  00 09 5b 2d 75 9a 00 0b  5d 20 cd 02 08 00 45 00   ..[-u... ] ....E.
0010  00 30 18 48 40 00 80 06  61 2c c0 a8 00 02 c0 a8   .0.H@... a,......
0020  00 01 0c 7c 00 50 3c 36  95 f8 00 00 00 00 70 02   ...|.P<6 ......p.
0030  fa f0 27 e0 00 00 02 04  05 b4 01 01 04 02         ..'..... ......

File: "D:/test.pcap" 14 KB 00:00:02                    P: 120 D: 120 M: 0
```

http://www.wireshark.org

Wireless Tools

- **inSSIDer**
  - Wireless network "sniffer"

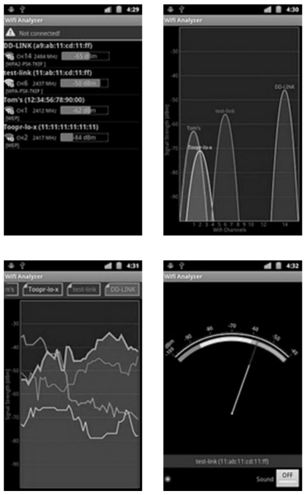




http://www.metageek.net/products/inssider/

Wireless Tools

- Mobile Apps
  - Android **WiFi Analyzer**
    - Graphical or tabular display of Wi-Fi networks in range
    - Shows signal strength vs channel or time
    - Similar functionality as inSSIDer but for mobile phone
    - Not available for iOS devices (Apple iPhone, iPad)



http://a.farproc.com/wifi-analyzer

https://play.google.com/store/apps/details?id=com.farproc.wifi.analyzer

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Questions?

- Thank you!

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